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WITH MANY DIAGRAMS AND ILLUSTRATIONS

VOL. I

THE BENNETT COLLEGE
SHEFFIELD

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Chapter I

WATER AND WATER SUPPLIES

The Necessity of Water.—Water is one of the prime necessities of life, as a pure and plentiful supply is one of the most important of health requirements. Water is a fluid or chemical compound composed of two parts of hydrogen to one part of oxygen, being reduced to two in the compound and expressed by the formulæ H_2O, but as water is one of the greatest solvents in nature, it is only found in this state of absolute purity by a process of distillation.

Pure Water.—Generally speaking, pure water is understood to be that which contains nothing prejudicial to health in the case of water used for domestic purposes, or nothing that would destroy the success of any technical operation, when intended for industrial purposes.

Relation to Health.—Water plays a large and important part in relation to public health and sanitation. A plentiful supply of pure water is necessary for the health of the people, as it is an important element in food. It assists the body by building up and repairing waste tissues, preserves the fluidity of the blood, aids in the excretion of waste and effete matters from the system, while it assists in maintaining uniformity of temperature in the body under varying climatic conditions. It is also required for cleansing purposes, for baths, sewers, water-closets, as well as for the use of animals and for trade and manufacturing purposes.

Rainfall.—The rainfall is the actual origin of all sources of water supply, and the quantity, whether plentiful or scarce, is dependent on the actual amount of annual rainfall either in the form of rain or snow. From the surface of the ground, rivers, lakes, and oceans, evaporation is continually taking place. This evaporation in the form of invisible vapour or moisture is retained in the atmosphere in quantities varying with the temperature of the air; the higher the temperature, the greater the volume of vapour which will be retained, but on the temperature falling, a

point is ultimately reached called SATURATION POINT, when the vapour retained in the atmosphere is no longer invisible, as it then forms into very fine globules and is visible as clouds and mist. Clouds are really only mist, their seeming solidarity being due to the fact that they are viewed from a long distance. Should a further fall in the atmospheric temperature take place, this moisture or visible vapour further coalesces into larger particles until these, by reason of their weight, can no longer remain suspended and are then deposited in the liquid state we call rain. Should condensation not occur until the temperature is below freezing point (32 degrees F.) the deposit takes a solid form which we call snow.

Average Annual Rainfall.—The average rainfall throughout the British Isles may be roughly said to be about 30 inches per year. The fall varies a great deal in different localities, from about 20 inches on the East Coast to between 70 and 80 inches on the West Coast of Scotland and Ireland, while in certain parts of the English Lake District 140 inches is no unusual amount.

Of this quantity of annual rainfall it must be remembered that it is not all available for use, as it has been calculated that, roughly speaking, one-third is absorbed by the ground (when it does not fall on an impervious surface), and this supports vegetable and plant life and feeds wells, springs, etc.; one-third flows off forming rivers, streams, and oceans; while the remaining third is evaporated.

Purity of Rainwater.—Absolutely pure water is not to be found in its natural state, except in rare instances, as, in descending in the form of rain or snow or in percolating through the soil, it gathers in its progress various mineral, animal, and vegetable matters which cause pollution. Thus it will be seen that in our rainfall we have, if properly handled, a valuable asset to life which has a great power for good, in purifying the air, promoting the growth of, vegetable and plant life, for driving machinery and giving wholesome drink to man and beast, but if misapplied, abused, or polluted, water then becomes a carrier of disease and death.

Physical Properties and Characteristics of Water.—Let us now look briefly at a few of the physical properties of water. It ought to be clear, colourless, sparkling, odourless, aerated, free from sediment, fresh to the taste, and moderately "hard."

Clearness.—Although water may be perfectly clear and sparkling it does not follow that it is free from disease germs or from pollution of some sort in solution, so that clear water is not always synonymous with pure water.

Colour.—The colour can best be judged by looking at the water through a glass jar, say 2 feet deep, with a white background. The purest waters have a bluish tint. A greenish tint denotes vegetable matter as a rule in the water. A yellowish tint denotes the presence of salts of iron or animal matter, while peat causes a faint brown or yellow discolouration.

Odour.—Pure water is odourless except in certain cases, where, when freshly drawn, there is a slight odour of ozone.

Taste.—Good drinking water ought to be pleasant to the taste and pleasing to the palate, due to aeration, without which it would be flat and insipid.

Purity.—The only safe way of arriving at the quality of water is by taking a sample (as described later), and considering the analyst's report, together with any possible source of pollution, relating to the water in question.

Sources of Water Supply.—The various sources of water supply for isolated houses, villages, towns, and cities are from rainfall, subsoil water, shallow wells, deep wells, artesian wells, springs, lakes, and rivers, and we will now deal with these individually, but first let us note the following valuable and important Report relative to water supplies.

The Rivers Pollution Commissioners' Report.—In a very exhaustive Report the Rivers Pollution Commissioners have summarised the characteristics of water from various sources as follows :—

Wholesome	1. Spring water,	Very palatable.
	2. Deep well water,	
	3. Upland surface water,	Moderately palatable.
Suspicious	4. Stored rain water,	
	5. Surface water from cultivated lands,	Palatable.
Dangerous	6. River water to which sewage gains access,	
	7. Shallow well water,	

The Commissioners have further arranged these waters in the following ascending order of hardness :—

1. Rain water.
2. Upland surface water.
3. Surface water from cultivated lands.
4. Polluted river water.
5. Spring water.
6. Deep well water.
7. Shallow well water.

Geological Strata.—Before dealing with each separate source of supply it may be as well to consider, without going deeply into the study of geology, the formation of the crust or

that part of the earth immediately below its surface. Fig. 1 shows diagrammatically how this crust is made up of layers or strata which were at one time rocks, but as they decayed, or because of some chemical action having taken place in the evolution of our planet, these have been converted into seams of many and varying compositions of matter called strata. Some of these strata are porous and permeable, while others which consist of clay, rock, or mineral seams are impervious. These strata are of varying thicknesses and rise and fall throughout their course, and at points come to the surface of the earth. The porous or permeable strata are water-bearing; being natural subterranean reservoirs, the water they contain is prevented from penetrating farther into the earth by reason of the impervious strata found immediately beneath them. It is these water-bearing strata we tap in sinking our wells, and the quality of the water from this source depends entirely on which stratum the water is drawn from. The water or rainfall penetrates the surface of the earth, and continues to descend until it meets with the impervious stratum, when its downward direction is diverted in the natural direction of the fall of the said stratum. This fall is usually in the direction of the natural water outlet of the area.

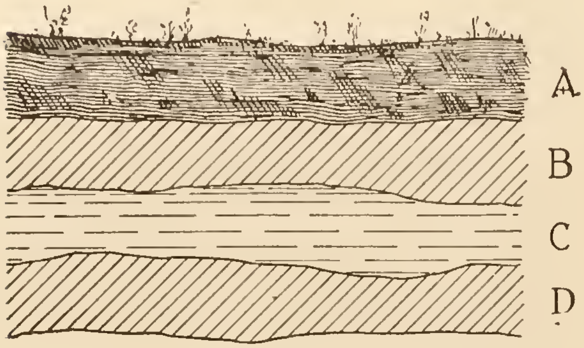


Fig. 1

The rate at which the water percolates through the soil will depend on the obstruction offered to its progress, the density or looseness of the ground regulating the speed with which it reaches the impervious stratum. Let us now look at the various types of wells got from these strata.

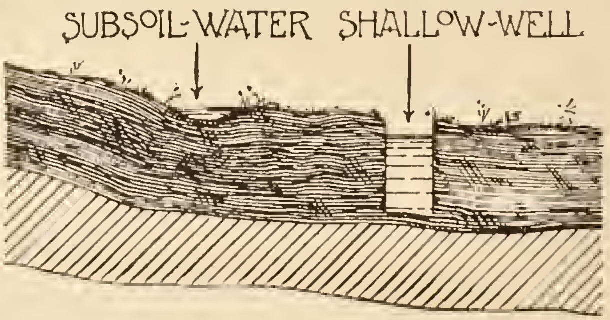


Fig. 2

Surface Water.—Surface water is the water found in ditches, hollows, marshes, etc., and in the stratum forming the earth's surface, it being retained there by an impervious stratum or layer underneath.

Shallow Wells, as shown in Fig. 2, are simply wells made to tap the subsoil water just described. They are very common in most

rural districts, and will be found to vary in depth according to the position of the underlying impervious stratum. The ordinary surface or shallow wells one meets with in the country are not desirable, because of faulty construction and the great risk of surface and subsoil pollution, together with the selection of the site. Too much stress cannot be laid on the proper method of well construction and the selection of the site. It must not be forgotten that these shallow wells often drain a very considerable surrounding area, and as a consequence it is not unusual to find pollution of the water from manure on neighbouring lands, liquid filth from a leaky drain, privy, midden, ashpit, or cesspool, etc. Moreover, as wells are often unprotected on the top, surface pollution of all kinds frequently takes place.

Deep Wells.—Beneath the stratum giving shallow-well water, we find, if we bore through the impervious stratum beneath, that we come on another water-bearing stratum, the water in which may have travelled quite a long distance. It is from this source that we draw water in sinking what are known as deep wells as defined in Fig. 3. It is important that in tapping for this type of well the boring should, as far as practicable, take place at the lowest part of the stratum. This has an advantage, in that in many cases the pressure of the water in the porous stratum tapped will cause the water to ascend in the well itself and so give it a shorter distance for it to be drawn up for use. With deep wells the danger of pollution, except from a surface source where the well is not properly covered, is not quite so great, assuming, of course, that the well itself is properly constructed.

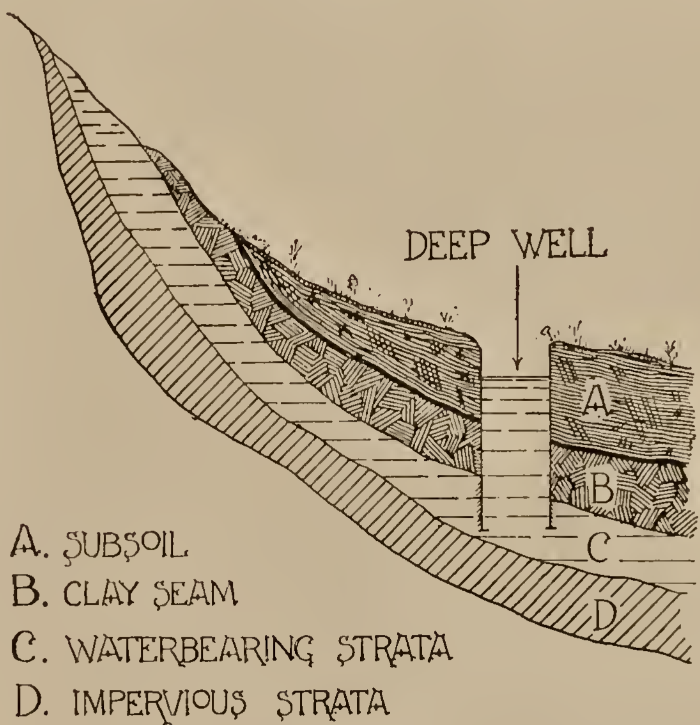


Fig. 3

Artesian Wells.—These are another form of deep wells which tap a saucer-shaped, deep, water-bearing stratum as indicated in Fig. 4, at its lowest point. Now this water-bearing stratum has its external ends at a considerable height above the

site selected for the well, and it therefore naturally follows that the water rises in the well and very often overflows. The water from this type of well is usually of good quality, provided, of course, that the well is properly constructed. It is important to note that even in long spells of dry weather a fairly plentiful supply of water can be obtained from both deep and artesian wells.

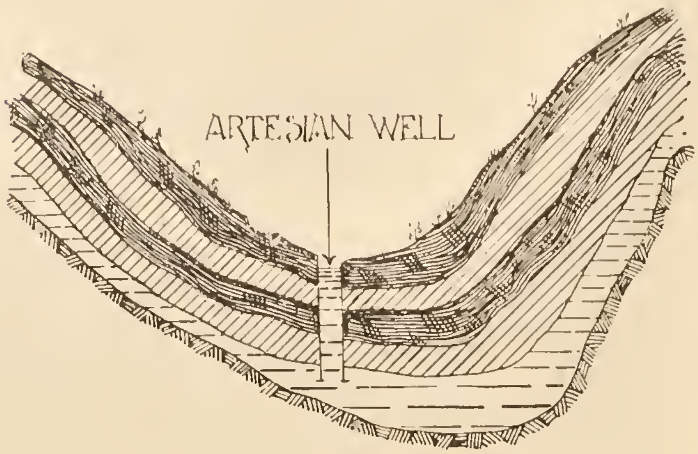


Fig. 4

Abyssinian Tube Wells consist of a series of tubes fitted together, and driven into the ground usually to a great depth so as to tap the water a long way below the surface; the lower length of the series of pipes is perforated, to allow of the entrance of water. The pipes are usually screw-jointed and driven down in lengths, the top length of the tube being fitted with a delivery pipe. The power for lifting the water up the tube is got mechanically as a rule.

Site for a Well.—It is important in selecting a site for a well that it be removed as far as possible from all sources of pollution and in the opposite direction to the natural water fall of the area, as in this way the water will be tapped before it reaches the point of pollution. Always make sure that the well is not constructed near any privy, cesspool, or midden. It is no uncommon thing in some rural districts to find a sump-hole for refuse water, etc., within a few yards of a poorly constructed well. Again, never resort to a shallow well if it is at all possible to go deeper down and tap a stratum for deep-well water, but never forget that even a deep well may be highly polluted if it is not properly constructed.

Construction of Wells.—From the foregoing, it will have been noted that the construction of a well is a very important matter indeed, and we will now consider how a well can be properly constructed so as to exclude, as far as possible, anything likely to contaminate or pollute the supply of water. The well itself ought to be built of brick, as shown in Fig. 5, built in cement down to the level of the water at least, while it should have a coating of puddled clay from 9 inches to 1 foot in thickness between the brickwork of the well and the surrounding soil as a further protection, as defined in the figure. It ought also to be

finished at the top with a stone or concrete cope, and have a stone slab or iron dust-proof cover. The finishing of the well at the surface of the ground, whether by stone slabs or concrete, ought to extend to at least a yard on the exterior of the well itself. The water ought to be drawn from the well by means of a pump, the nature of which will depend on how far the water has to be

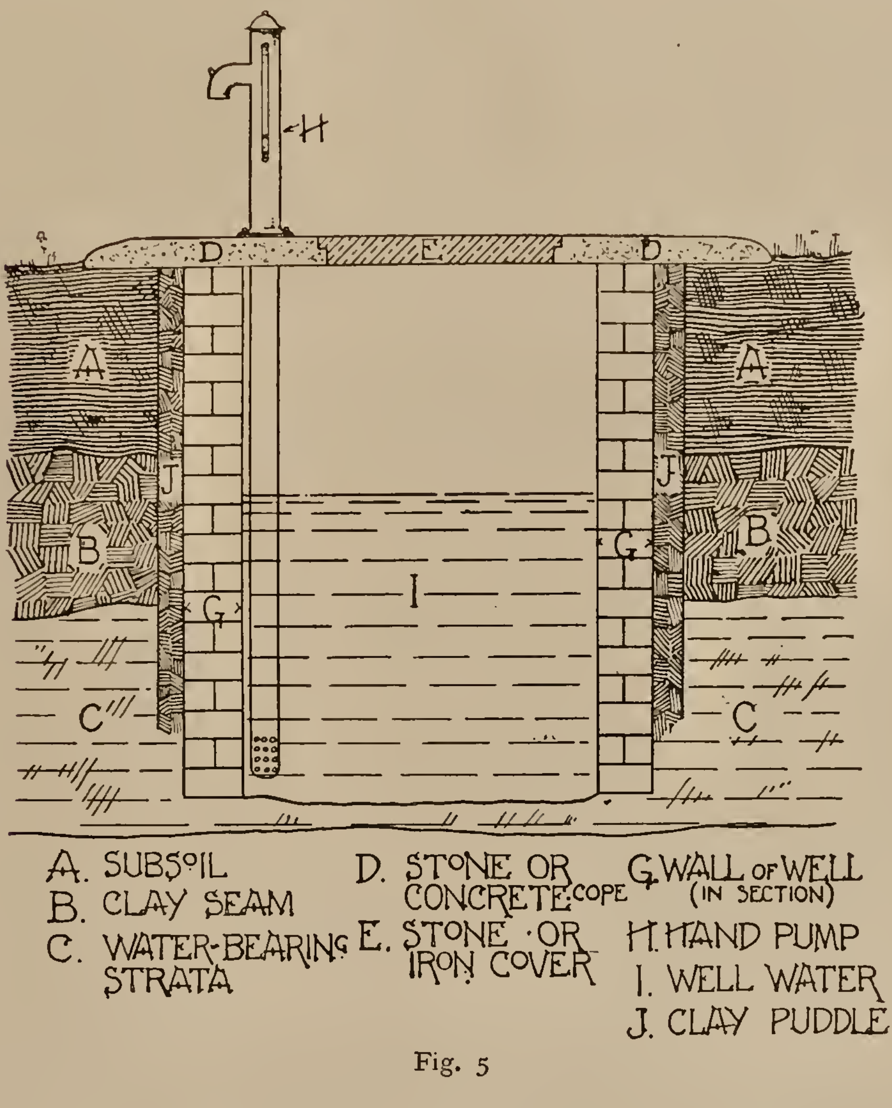


Fig. 5

raised. The old-fashioned method of drawing water by means of a windlass with rope and bucket ought to be done away with, owing to the great amount of surface pollution which takes place. It is very essential that all wells should be examined periodically to ascertain exactly their condition. An inspection of the interior of the brickwork should show it clean and fresh. Should there be any pollution anywhere from a fissure in the construction of the well, the stained or discoloured brickwork will at once be noticeable.

Pumps.—As already stated, all wells ought to be fitted with pumps, and of these there are quite a large assortment of varying kinds and designs. In practice it will be found that the common suction pump will not act with very great success when the water surface of the well is over 20 feet deep, and so we come across some very good and useful as well as ornamental types of mechanical pumps. Among these are various types of petrol and oil-driven engine pumps and gas engine pumps, while a popular form with farmers is the windmill pump. These latter are now a very prominent landmark on many of our country landscapes,

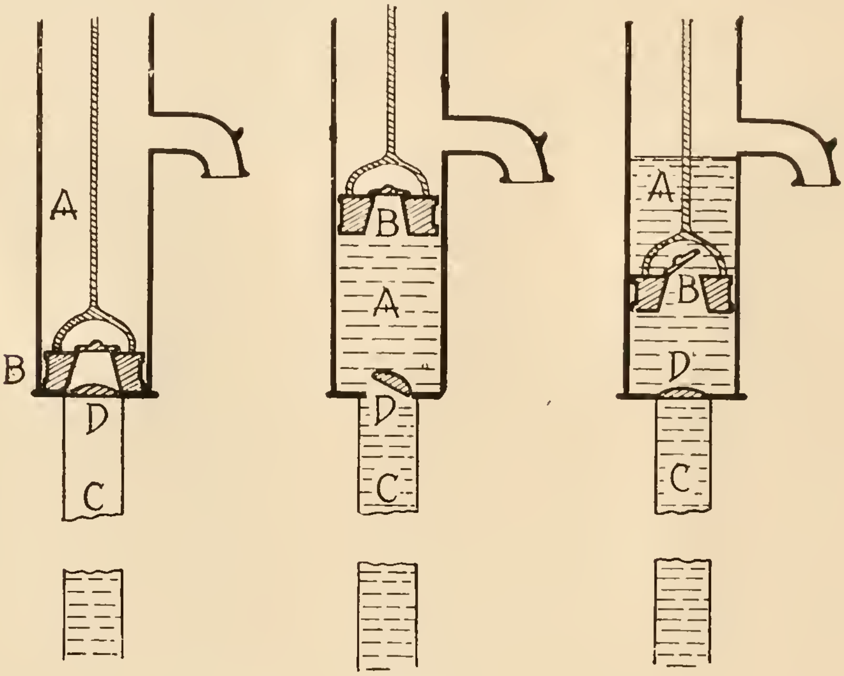


Fig. 6

and in many districts they have been highly successful in raising water from a low level. These mechanical pumps are only used as a rule where there are a few houses together, a farm, or a village. The commonest pump is the old-fashioned suction pump defined in Fig. 6, examples of which are to be found all over the country, hence a brief description of its action will be found of service. Briefly, then, the water is raised in it as follows: on the pump rod being raised, a partial vacuum is created in the barrel *A* (see Fig. 6), and the pressure in *C* forces open the valve *D*, allowing the water to pass upwards. On the down stroke of the pump rod, the valve *D* is closed, the water being retained in the barrel *A*, which forces the valve *B* open, and thereby allows the water to pass above the ram. As this action is repeated, the water continues to rise in the barrel until it overflows at the outlet or spout of the pump.

Windmill Pump.—We will now give a description of a windmill pump used for raising water in such a manner that a gravitation supply is provided. This method of water lifting is economical, and is very satisfactory where the wind is fairly constant. Where the wind is only intermittent such a pump would not be very serviceable as, of course, one would have periods when a plentiful supply could be obtained, while in periods of calm weather, no water worth mentioning would be raised. In the type shown in Fig. 7 the apparatus consists of a storage tower or tank of steel, supported on iron pillars. On the top of the storage tank is fixed a simple wind engine of single crank drive, which works, by means of a horizontal shaft, a vertical shaft connected to a double barrel set of deep well pumps. A steering wheel keeps the head of the engine, in this case the large sails, to the wind, and the vanes are arranged to open automatically against an excessive wind pressure, and thus avoid damage to the works.

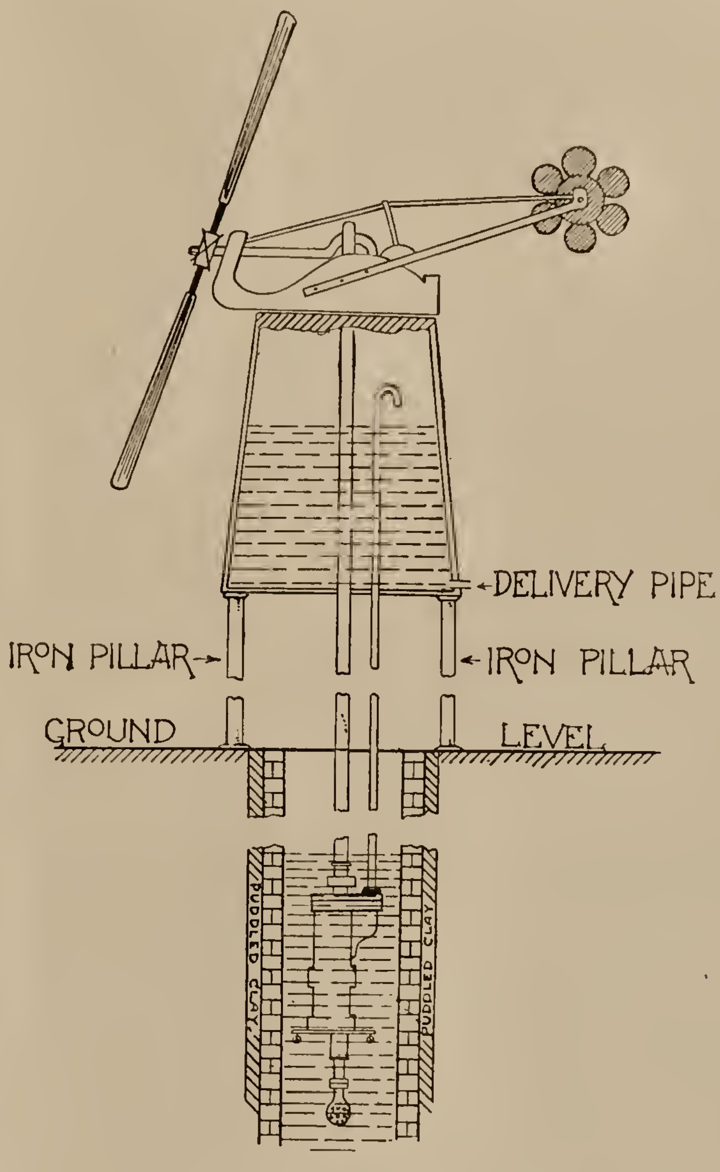


Fig. 7

Water Rams.—In addition to pumps as a means of raising water, what is known as a hydraulic or water ram is often employed when the supply is from a stream or small river. This machine, shown in Fig. 8, is very moderate in its initial cost, requires little attention, costs nothing for power, and is a very desirable and useful apparatus. The action is very simple. The machine itself is built into a prepared recess made in the bank of the stream or river. A lead pipe or drive with a fall of one in ten (1-10) conveys the water from the stream to the ram. The

motive power is due to the momentum of the water in this drive pipe rushing through the apparatus and escape valve which opens inwards. This rush of water meets with resistance from the air chamber which closes the escape valve, thereby preventing water getting back that way. The resultant check forces the water to seek another outlet, which it tries to find in the air chamber. The air, being now under a measure of compression, begins to assert itself and expand to its original volume, and this forces a portion of the water up the delivery pipe, and the closing of the delivery valve prevents its return. In the meantime the escape valve has again opened and the pressure having been relieved by the recoil of water, the operation is repeated, and the water raised by a series of impulses.

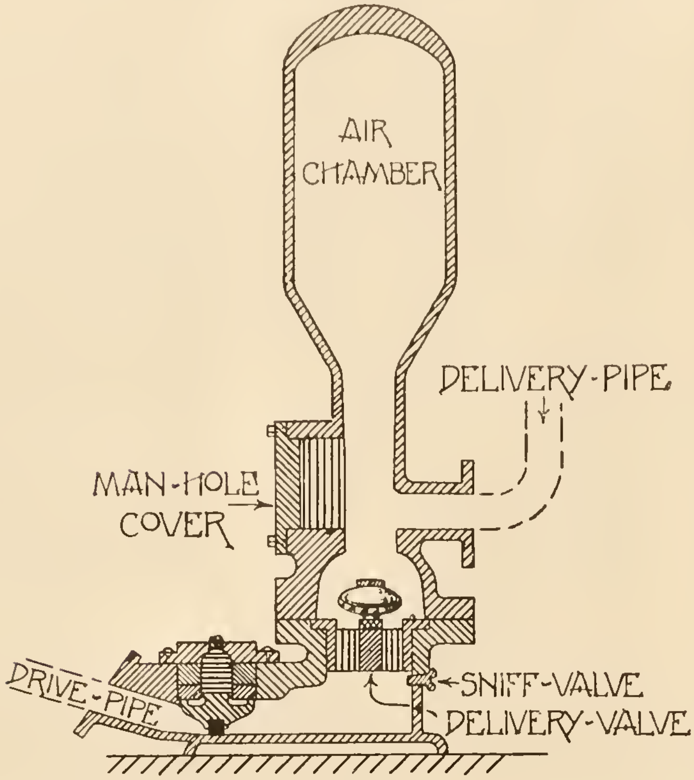


Fig. 8

An efficient ram, situated in a suitable position, will force one-third of the drive water to two and a half times the height of the fall given in the leading-in pipe, one-sixth to five times the height of the fall, and one-tenth to eight times the height of the fall. From this, it will be seen that such an appliance is indeed a boon to isolated houses in country districts or to farms and farm houses.

Springs are, practically speaking, overflows of water from the earth, at points where the water-bearing strata comes to the surface, and the pressure of water in the stratum, owing to its height at some particular part, forces the water to the surface where it runs out. In deep springs a fissure in the impervious stratum, above that carrying the water, enables the water to rise to the surface. It is a noticeable

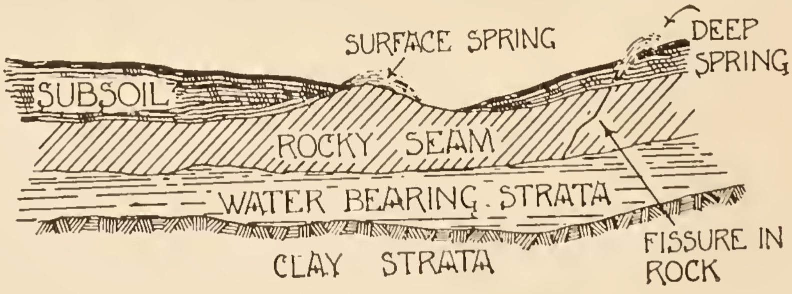


Fig. 9

fact that these deep springs seldom, if ever, go dry. As a source of supply, spring water is very good, and where the number of people to be served is not large, and proper precautions are taken to ensure its freedom from pollution, it is very satisfactory (see Fig. 9).

Rainwater as a Supply.—In many country districts, the rainwater is the main supply of water for domestic purpose, especially where the houses are scattered and the depth that has to be tapped for wells is too considerable. The water falling on the roofs of the houses and buildings is led by rhones, spouts, and gutters to butts, barrels, or tanks for storage. When this is the case, the following points should have attention. The roofs should have no lead on them and be as clean as possible, free from dust and soot. Keeping in view the fact that rainwater is a great solvent, no lead must be used for rhones, gutters, spouts, or in connection with the storage arrangements; while it is desirable to make use as far as possible of the height of the roofs, so as to have a gravitation supply.

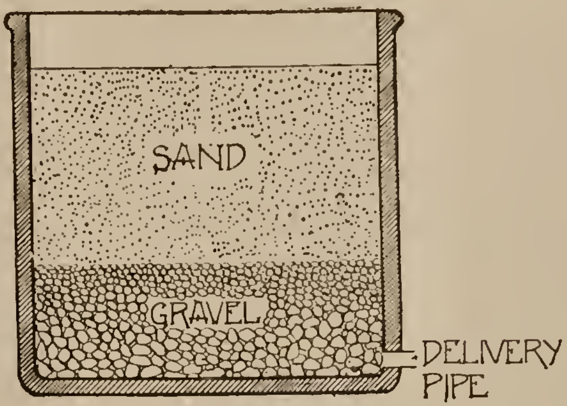


Fig. 10

It must not, however, be forgotten that before use the water ought to be filtered. A suitable filter for this purpose is shown in Fig. 10.

Roof rainwater is often used to augment a scarce supply. The water is stored in tanks or barrels, and used for washing and laundry purposes, flushing water-closets, and drains, and also for baths. In this way, the quantity of water required for drinking and domestic purposes is kept at a minimum, which is a big consideration where good water is scarce or has to be conveyed long distances.

Hard and Soft Water.—The difference between these two kinds of water is that the former contains more than a certain quantity of bicarbonate of lime or other salts in solution, whereas the "soft" water contains very little—if any. In simple language, the terms denote the ease with which a lather can be formed with soap. With "hard" water it is difficult to do so, the reverse being the case with "soft" water. The hardness is obtained by the addition of carbonates, sulphates of lime and magnesia, to the water, while occasionally chlorides and nitrates are used.

Degrees of Hardness.—Dr. Clarke's scale of hardness in water is: 1 grain of chalk, lime, or other salts dissolved in 1 gallon of water (70,000 grains of water in 1 gallon) equals 1 degree of hardness.

Up to 6 degrees water is regarded as "soft," while from 7 degrees and upwards water is said to be "hard." Hardness of water up to 16 degrees or 17 degrees does not appear to be prejudicial to health, except in very exceptional and peculiar diseases. Hard water cannot be used for certain trade purposes—unless softened, such as wool washing, calico printing, bleaching, dyeing, or any other business where soap is extensively used.

Temporary and Permanent Hard Water.—Hard water may be only temporary or permanently so, according as to whether the salts or carbonates used for hardening can be precipitated on boiling or not. When these salts can be precipitated the water is only temporary hard, but if the chemicals will not deposit on boiling it is then known as permanent hard water. Temporary hard water is not good for using in boilers, owing to its "furring" action, due to the deposit of the lime salts. For this reason, in places where the supply for boilers, etc. is from a temporary hard source, water softeners are used before the water passes to the boiler.

Clarke's, Maignen's, and Nessfield's Softening Processes.—In some places what is known as "Clarke's process" is used, which consists in adding enough lime to combine with the $C.O_2$ and so precipitate all the carbonates in the water. This method is only for use with temporary hard water, but another method—Maignen's Anti-calcaire—is said to remove most of the permanent hardness as well. This is done by adding lime, alum, and carbonate of soda. These carry down all organic refuse, and remove the carbonates and salts in the water. Such processes are mostly for treating water for industrial purposes. For domestic water, should it be necessary to remove the hardness, Professor Nessfield's process might be applied. For this iodine is added to the water, and is then converted into a soluble salt by salt of soda. It is claimed for this method that it purifies drinking water of all organic and dangerous deposits, to kill all bacteria in one minute, and thus render the water clean, harmless, and palatable.

Action of "Soft Water" on Lead Fittings, etc.—Soft water must not be stored in lead cisterns or conveyed through lead pipes, as, owing to its soluble action on lead, it may give rise to lead poisoning to the people using the same. It is interesting to note that one-twentieth of a grain of lead dissolved in a gallon of water may give very serious results, and must therefore be considered highly dangerous and unfit for drinking.

Action of "Hard Water."—Hard water, on the other hand, forms an insoluble protecting coat, chiefly of sulphate of lime, not only on all lead surfaces, but also on all other materials used for the storage and distribution of water.

Chapter II

WATER SUPPLIES OF LARGE TOWNS, ETC.

So far, we have merely considered the sources of water supplies for villages, scattered country districts, and isolated houses, etc. Let us now look at the sources of supply common to cities and large towns. Owing to the large population which has to be served, no less than the large industrial concerns within the towns, a very great volume of water and consequently very large reservoirs are necessary to meet the daily requirements. The water supply is always an important undertaking in any large community, and calls for proper and efficient management.

To provide a sufficient and reliable water supply in all seasons, corporations either acquire the right to some large lake or lakes, or resort to the process of damming a river where, in some part of its course, it flows through some valley or natural hollow area. The building of the wall for damming the water, the fitting of sluices and overflows, all call for expert engineering skill in their construction. In both lake and river supplies of water, the nature of the surrounding lands, and the erections or buildings thereon must be taken into consideration when estimating the quality of the supply itself, as the surface of this collecting area must necessarily have its drainage into the river or lake, and for this reason corporations always make a point, as far as possible, of owning or controlling the surrounding ground or catchment area.

Lakes.—Dealing with this source of supply first, one must admit that the quality of the water from these is invariably good. The lakes being fed by mountain streams which contain very good water, and which is very little polluted, form a natural and dependable reservoir, and the cost of constructing a wall to dam the water is thus saved, while a plentiful supply of good water is always available. As a general rule these lakes are usually a long way off from the town to be served, so that the water has to be conveyed a long distance before it reaches the consumer, and this, of course, entails a good deal of expense and supervision of works.

Dealing now with **River Water** as a source of supply for

large communities, we find, as already stated, that this is done by damming the river at some part of its course, by building a wall across it, and thus forming a large artificial reservoir, which ought to be of sufficient capacity to give a full and plentiful supply even in long spells of dry weather. With this source of supply there is, of course, always an element of danger from pollution should the river pass through cultivated land, or if there are houses situated anywhere on its banks. The first of these dangers arises from the manure which is, from time to time, placed on the land, and which, of course, the river drains; the second source of danger is from the sewage or refuse from any houses on the river banks, or it may be from some farm buildings set down near to the river itself. It is interesting and reassuring, however, to know that after careful investigation it has been found that the natural process of purification of sewage in rivers is performed by vegetation in the water, which oxidises it by dilution and precipitation. Indeed, it is held that many of the deadly micro-organisms, instead of multiplying in river water, soon decrease and die out, and from this one learns that the pollution of a large river by infective germs, while not desirable, is of little danger as compared with the contamination of wells and streams, as in the former germs evidently tend to disappear, while in the latter they would appear to multiply rapidly.

With regard to the provisions for the **Storage of Water,** we have seen that where lakes are the source of supply nature has provided the necessary storage accommodation, and where rivers are utilised for the purpose considerable expense is incurred in building the damming walls, sluices, overflows, etc. Where the supply is from wells, pumps and tanks require to be erected, the tanks to be of sufficient capacity to provide for several days' supply at all times.

Where **tanks** are necessary, they are usually constructed of stone or brickwork built in cement and having the interiors rendered in cement and finished with a smooth impervious surface. Reinforced concrete may also be used for the purpose, or a combination of steel framing having the sections filled in with cement concrete. All tanks should have proper means of ventilation provided, while they should be properly covered and fitted with manhole covers as a means of entrance to them for inspection, and also to facilitate repairs if necessary. In the very large type of tank reservoir, doors, of course, will be fitted. Periodic inspection of tanks should be made to ascertain their condition and freedom from pollution.

When the water leaves the lake or river supply as the case may be, for its distribution in the town to be supplied, it is neces-

sary to remove any impurities and harmless suspended matters that may be in it, by passing the water through what are known as **Filter Beds.** These filters are very efficient besides being very simple. They are constructed in series at the point of outlet from the source of supply.

In making they require very little technical skill, and can be constructed of any size conforming with the volume of water that has to be dealt with. In Fig. 11 we get an idea of how the filter is put together. On the top is a layer of fine sand, below which is more sand not so fine and sharp and angular. This complete layer of sand varies from 1½ to 2 feet in thickness. Beneath this layer of sand is a course of gravel 3 feet deep. This gravel ought to be graduated from very fine pebbles on top to small stones at the bottom, where the outlet pipes are. It is a good method to finish at the bottom of the filter with stone setts or blocks having a small space between them where the water may gather. The whole filter ought, of course, to be built on a properly constructed concrete base or bottom. There is one more layer in connection with such a filter bed which plays a very important part in purifying the water, and that is the deposit or "jelly" which the water makes on the top of the bed, but that part of the process is supplied by the water itself.

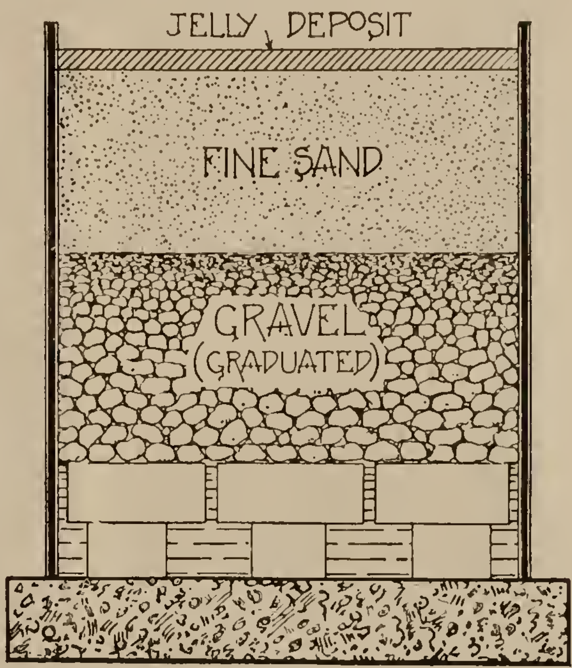


Fig. 11

Now *the action of a sand filter* is both bacterial and mechanical. Bacterial, in that it removes dissolved organic matter by the presence of air in its interstices and by the deposit which forms on the surface of the filter bed after being a short time in use. This deposit is a jelly-like substance or scum. So long as water will pass through this, it ought not to be disturbed or interfered with in any way as it really consists of innumerable bacteria, constituting a living filter; the crowding microbes on the surface penetrate into the sand, nitrify the organic matter, and destroy poisonous germs. It is worth noting here that a brand new filter bed which, of course, has no surface deposit does not give nearly so good results in purifying the water passing through it as does one which has been some time in use and consequently has the

scum on top. Indeed, the first water passing through a new filter is never treated as being good-quality drinking water. The filter is also mechanical in its action because of the straining effect of the sand and gravel, not to mention the surface deposit, through all of which the water has to pass. It is the presence of air within the filter bed which accounts mainly for increasing the purity of the water and also for properly aerating it, and for this reason it is important that the filter bed should be rested occasionally in order to allow it time to aerate properly. As a matter of fact, when filter beds are constructed to deal with a water supply, the series of filters ought to be so arranged in such a fashion as will allow them to be worked intermittently, and in this way splendid results will be obtained. The quality of the water treated depends also to a certain extent on the length of time it takes to pass through the filter, and this is regulated by the depth of sand placed in the top layer. A modification of this type of filter is often used with rainwater sources of supplies (*vide* Fig. 10), and is found to give very good results.

The **Pipes or Mains** used *for conveying water* for the supply of a large town, be it from a lake or river, are usually carried a long distance before reaching the distributing points. Many methods of conveying water are employed, among them being brick-built aqueducts, stoneware pipes, and heavy cast-iron or steel pipes. These mains, as they are termed, require great care and preparation in their construction. In laying out water mains the first consideration, of course, is the volume of water that has to be conveyed and the consequent pressure that must be reckoned with and provided for. Brick-built aqueducts finished internally with cement coating are very good for large supplies of water, but the question of cost is a very serious one indeed, and this fact leads to the consideration of less costly means of conveyance. Stoneware pipes either vitrified or treated with salt glaze may be all right for small supplies, although even with these their liability to get fractured, and the fact that they may be improperly laid in the track so that breakages occur when the soil is filled in on top of them, render them of little account when dealing with a supply for a large community. Cast-iron or steel pipes for water mains have found much favour and have given complete satisfaction in this class of work. It must be remembered that the water passing through the main is soft and therefore solvent, so that if iron or steel pipes are to be used they must be specially treated. We will therefore now consider one or two methods of protecting these pipes against the action of soft water, which of course, acts very quickly on unprotected iron or steel pipes.

For instance, **Dr. Angus Smith's Varnish** is the commonest

method of treatment of iron or steel pipes and has proved very successful. It consists of coating the pipe with a specially prepared varnish which protects the pipes against the action of the water. Being cheap in price and easily applied, besides being very reliable, it is the kind of protection mostly used.

Now the **Bower Barff Process** is another, though more expensive, method used in the protection of iron or steel pipes. This consists of raising the temperature of the pipes to white heat (about 1200 degrees F.) in a specially constructed chamber for the purpose, into which superheated steam is passed. After being exposed to the action of the steam for several hours, a protective coating of oxide is formed on the metal. It is unnecessary here to deal with more than these two methods of protection against the action of the water in large mains. It will, however, be expedient to consider some of the types of pipes used where only a small supply is concerned. In some instances **glass-lined iron pipes** are used, and while they are very satisfactory they are not very universally used owing to the heavy expense incurred in their manufacture. **Galvanised iron pipes** give satisfaction where used with a small supply, although certain authorities assert that there is always a danger of metallic pollution with them. In practice, however, one finds little to justify this assertion.

One other kind of pipe, not very often met with, however, is used for the purpose and known as the **block-tin lead pipe.** Here, again, we have a type which is only suitable for small supplies and where the water has to be carried short distances. This consists of a lead pipe with a block-tin lining and is rather costly in production.

Distribution.—The water having been conveyed from its source to the town to be supplied, it is usually led to specially constructed reservoirs for distribution. Here the various chemicals used for "hardening" the water are usually added to it. Those reservoirs call for no special comment other than the fact that they are well-built structures of stone, brick, or concrete, well lit and ventilated, although the lighting is so arranged as not to allow the heat from the sun's rays too great scope, while they have a storage capacity commensurate with the consumption of the district which they have to serve.

Two **methods of supply of water** or means of distribution may be met with, namely, the Constant Supply and the Intermittent Supply. **A Constant Supply** is the best, as this gives a constant supply of water from the mains to the taps in the various houses served.

With the exception of hot-water systems and water-closets, no storage in cisterns is necessary, which is a very important con-

sideration indeed, as all unnecessary storage not only means increased expenditure in the fittings but, more important still, the risk of pollution is great, while stored water always deteriorates. Again, there is always a ready and abundant supply of good water for domestic purposes with this forenamed system. The principal disadvantages urged against the constant system are that the water being always under pressure, the fittings and joints must be of first-class workmanship throughout, while, should there be a leaking joint or faulty pipe, the wastage of water would be very great. As, however, we are always insisting on the best materials and workmanship in all matters of sanitation, this can hardly be considered much of an argument against the use of this system. Another argument is that where there are careless or indifferent tenants or occupiers of property, a very considerable wastage of water may take place. On the whole, however, there is really nothing to advance against the system unless it be that the source of supply calls for special measures of restriction in the use of the water, and in that case one usually finds the alternative method of distribution in operation which we will now consider.

With an **Intermittent System** cisterns are necessary for storage, as the water is turned off and on at intervals. This entails a good deal of work in turning off and on the water, while the water is bound to deteriorate through storage and possible pollution. By the periodic shutting off of the water, a partial vacuum is liable to be created in the pipes, and should there be any leaky joint, this vacuum may become charged with foul air or gases. Also pipes which are not always full are more liable to rust. If a separate water main has not been laid down, much inconvenience and possible increased loss of property will take place should a fire occur.

Where **cisterns** are necessary for storage of water, precautions as to their situation and construction require careful consideration. They should never be constructed of a material that may impart any injurious quality to the water. A good deal depends on the quantity of water to be stored, and consequently the capacity of the tank required. When large storage cisterns have to be constructed, these may be built of brick, stone, or reinforced concrete, coated internally with cement finished with a smooth surface, and the bottom, of course, of cement concrete. Cisterns of what might be termed intermediate size are often constructed of a metal framework, the sections being filled with cement concrete, thus giving in effect a reinforced-concrete tank. Among smaller cisterns we come across a great many different types in use; the most satisfactory materials for these are stone, slate, fireclay (finished with leadless glaze enamel),

zinc, galvanised iron, and wood. Enamelled fireclay tanks are very good, although, as a rule, they cannot be constructed of a very large size, owing to difficulties in manufacture. Slate is a very good material for a small tank, but it has two disadvantages, the first is the great weight of such a cistern, and the second is the difficulty of making proper joints. White lead is often used for this purpose; this wears away quickly and causes leaks, therefore it is no uncommon occurrence to find that the tradesman has made the repair with red lead, which imparts very injurious matter to the water. Stone cisterns are very satisfactory also, but suffer from the same drawback as slate, *i.e.* their weight. Wood cisterns are often met with. These are made of some hard wood such as oak, ash, teak, or some such wood, and in many cases give a good deal of satisfaction, although it is not always the best policy to make use of wood for this purpose. Wooden tanks lined with lead are not to be recommended, as sufficient has already been said of the action of soft water on lead to guard the student as to this. If hard water is being stored, then they may be employed with a certain amount of satisfaction. Zinc and galvanised iron are common types of cisterns in use all over the country. These types, however, are often blamed for metallic contamination of the water they contain, although by reason of the large number in daily use, and the fact that no really bad results have been traced to them, this allegation would seem to be disproved. We will now consider some *precautions as to cisterns*, which should receive strict attention :—

1. The cistern must always be situated in a well-lit place where easy access can at all times be obtained, and where the sun's rays do not shine on it. Too often one finds cisterns stored away under roofs, in cupboards, or any out-of-the-way place or odd recess.
2. All cisterns ought to be covered in and ventilated so that dust, dirt, or, as sometimes happens, vermin can be excluded.
3. An overflow pipe ought to be provided to carry off any surplus water from the cistern. This pipe should be carried through the external wall of the building and cut short, and a hinged disc flap fitted on the end of same. This overflow pipe must on no account be connected to any other pipe, except in certain cases to another overflow pipe, otherwise the purpose for which it is provided will not be served, *i.e.* of drawing attention to the cistern when out of repair; whilst if the overflow be connected to any other pipe, it might be the means of conveying foul air or gases to the cistern.

4. No cistern used for storing water for domestic purposes must be directly connected with any water-closet, as, if such was the case, foul air and gases would in all probability find their way to the cistern.
5. All cisterns should be periodically emptied and cleaned.

The **service water pipes** used in connection with houses, factories, etc., are mostly of lead or composition, and, assuming that the water has been treated and is consequently "hard," no contamination of the water from this source need be feared. Both these types of pipes are very suitable for the purpose, and, as they can be bent round corners and projections of walls with ease and no damage to the pipe, they are very convenient for this form of work.

Other kinds of service pipes used are galvanised iron, which answers the purpose very well, although they cannot be bent so easily in following a wall, and further they corrode very readily.

Lead and block-tin pipes are sometimes used, where the water is "soft," while tin-lined pipes are sometimes introduced for a similar purpose.

Precautions ought always to be taken, when putting in all service water pipes, *against frost.* Now, it is a sound investment to protect these, as the initial cost will be more than saved should burst pipes happen after the house is occupied. Where pipes have to be led along an external wall, this is especially the case. A good method is to have all such pipes boxed in, the space being filled with cocoanut fibre around the pipes. Another method is to interpose a piece or strip of wood boarding between the pipes and the wall, or the pipes may be covered with felt or gasket. Both of these form a good means of protection from frost during winter.

Pumps are usually protected in country areas by having straw bound round them.

Impurities in water may be produced at the source of supply, in transit, in distribution, or in storage. Having already seen how lead pipes and fittings with "soft" water, or unsuitable and badly situated cisterns, etc., may lead to contamination, we will now discuss another source of danger and impurity. This might be said to be the chief impurity, and one which gives a great deal of trouble, namely organic matter, vegetable or animal, in solid or solution found in water. Of the two, the latter is by far the more objectionable.

Where impurity exists in solid form, the water is, of course, distinctly discoloured and attracts attention, while in the case of organic matter in solution, the water, although highly polluted,

may be quite clear, sparkling, and wholesome looking; yet it may be very badly tainted and highly dangerous to those drinking it. In all cases where there is any suspicion of the purity of the water, the only remedy is to take a sample and have it analysed. At the same time a sample might be sent to a bacteriologist for examination in order that he may find if it contains any disease germs or not. It is a well-known fact that many of our infectious disease germs find an entrance into the human system through the medium of drinking water, which acts as a carrier of the bacteria of the disease. Indeed, in the case of typhoid fever, to mention no other, the source of water supply receives, or ought to receive, very careful consideration, as many outbreaks of this disease have been traced to a polluted water supply. Putrefying matter may be present in the water, or even liquid filth may have found its way into the water, but this will usually be noticeable by the odour which comes from the water, especially if it should happen to be heated for any purpose.

As already stated, where the quality of any water gives rise to suspicion, a sample should at once be taken for analysis.

In *taking a sample of water*, a Winchester quart bottle, with glass stopper for preference, should be used. The bottle should be scrupulously clean, and before being filled it ought to be rinsed out three or four times in the water to be sampled.

Another point worth noting is that, if the water is from a stream, it should not be taken just beside the bank, but as near the middle of the stream as possible. Having filled the bottle, put in the glass stopper (if not provided with a stopper use a clean new cork); over this, place a piece of clean, washable leather, and fix with a piece of string, which must be sealed with sealing wax. It would, of course, be of very little use to take the sample without noting some particulars regarding it. Hence then it is necessary, and in many ways desirable, to collect the following particulars for reference and assistance. These may be written on a gummed label and attached to the sample after it is sealed, a copy of them being kept for any further developments. The list of particulars to be taken is as follows :—

1. Name of Authority taking the sample.
2. Nature of source of water (pump, well, etc.).
3. If a well, state how constructed, depth, etc., and how far from any possible source of pollution such as privy, midden, drain, etc.
4. If from a pump, what is it made of?
5. If water is from a tap, give nature of pipes and fittings.
6. Reason for taking the sample.

7. Any special particulars to which attention should be drawn.
8. Date on which sample was taken.
9. Name of person taking sample, and nature of his appointment.

Domestic Filters.—In dealing with the many and various types of alleged filters in domestic use, we must admit that the amount of ignorance that prevails with regard to these is, to say the least, surprising. There is really no great necessity for such appliances when the water is from a reliable source, but where, from various reasons, people find that some form of precaution is necessary, only a reliable domestic filter ought to be used. It is no uncommon experience to find old bits of flannel tied round the tap, or cheap wire gauze contraptions fitted, which are put on the market at a "catch-penny" price, and often looked upon by the inmates of a house as being a complete protection from anything of a harmful nature which the water may contain.

These cheap so-called filters are worse than useless, as not only do they lead the people using them into a false sense of security as regards the water passing through them, but worse still, one often finds they are fixed on the tap and allowed to remain there as long as they will hold together, while they very quickly become culture beds for various micro-organisms, in addition to causing metallic pollution of the water passing through them.

The **Pasteur-Chamberland Filter** is one of the best types and patterns of pressure filters for domestic use on the market, having stood some severe tests and proved reliable and safe to use. This filter, shown in Fig. 12, was desgined by M. Pasteur and his principal assistant, M. Chamberland, from whom it takes it name.

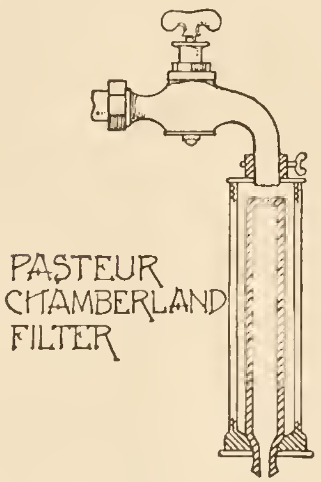


Fig. 12

Its construction is as follows: The outer casing or cover consists of a metal cylinder which has a screw-socket attachment at the top for fixing the filter to the water tap, while the lower end of the tube is open to take the nozzle part of the filter "candle." Inside this metal tube or cylinder we have the filtering medium in the shape of a "candle," which, of course, is hollow in its interior. This "candle" consists of a specially prepared fine-grained, unglazed piece of porcelain. The action of the filter is purely mechanical, and requires the assistance of the pressure of water from the mains. The water enters from the tap

into the annular space between the outside cylinders and the candle, the pressure forcing it through the porcelain, thus the straining effect of this process rids the water of any of its impurities. The filtered water then passes down the inner cavity of the "candle," and so to the consumer. These porcelain candles require to be cleansed periodically, and this fact is really an additional advantage to the filter, as no sooner does it require cleaning than attention is drawn to the matter by the slowness with which the water passes through the filter. The operation itself of cleaning the filter is very simple indeed, as it is easily taken to pieces and the porcelain "candle" removed and cleaned by brushing it under a running tap.

Now a **Berkefield Filter,** to take one other reliable type of pressure filter, differs very little in external appearance from the one just described although there is a vast difference in the filtering medium. Here again, as seen in Fig. 13, we have a metal outer case or cylinder so constructed as to be easy of adjustment to the water tap, and having an aperture to take the lower end of the candle where it projects through the case at the bottom. The inner cylinder or "candle" is considerably thicker than that in the Pasteur-Chamberland filter. This "candle" is composed of Kieselguhr, a diatomaceous earth. This matter is rough in comparison with porcelain, and is also more porous and brittle than porcelain. The action of this filter is similar to that already explained for the preceding filter. The water enters the annular space between the two cylinders, and the pressure forces it through the filtering medium which purifies the water during the straining operation.

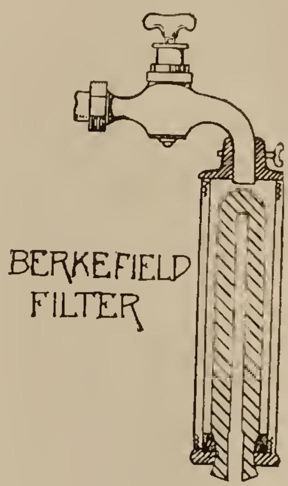


Fig. 13

As has been pointed out, both the filters just described depend upon the pressure of water in the mains in order to be of any use. In cases where no such pressure can be obtained, another method of filtration must be employed, as shown in Fig. 14, where we have a very satisfactory filter known as the **New Carbon Filter.** This really consists of a chamber within a chamber, the upper one in which the water is placed being fitted with a series of carbon tubes or candles through which the water percolates, and, passing down the hollow interiors of the candles, drips into the lower chamber from which it is drawn by means of the tap provided. These filters are made to take varying quantities of water according to the size of the house where used. Where small quantities of water are required, and there is reason to take some sort of precaution but no appliance is at hand for the purpose

boiling as a means of purification is a very good and simple method of treating the water. By raising the temperature to boiling point (212 degrees F.) it is found that disease germs cannot withstand this moist temperature for even a short period. Objection is, however, taken to the fact that this treatment renders the water flat and insipid, but even that is preferable to using water containing any dangerous properties. Now, water which has been boiled will remain fresh for at least twenty-four hours.

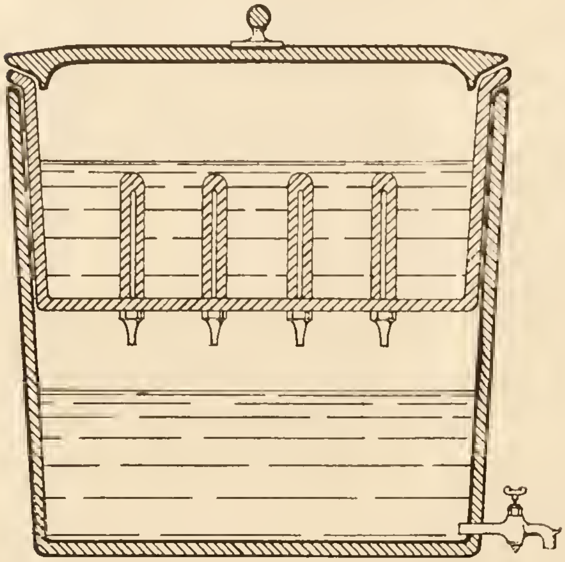


Fig. 14

Among the many agents used as *filtering mediums* with water are charcoal or a combination of charcoal and silica, spongy iron, magnetic carbide of iron, etc. Another method of purifying water is by adding bisulphate of soda in the proportion of 15 grains to every pint of water.

The *quantity of water required per head of population* may be said to vary according to whether the supply is an abundant one or otherwise. There is a great diversity of opinion as to just how many gallons per head per day ought to be allowed.

Taking four of the largest towns in the British Isles, we find they have a daily supply as follows, viz. :—

London . . .	30 gallons daily per head
Dublin . . .	35 ,, ,, ,,
Edinburgh . .	40 ,, ,, ,,
Glasgow . . .	50 ,, ,, ,,

Many other towns equal these amounts, and some even surpass the quantities as quoted.

Hospitals usually have a daily allowance of from 60 to 90 gallons per head per day. It is highly desirable that an abundant supply of good, pure water, not only for domestic purposes, but also for baths, etc., should be provided. This, of course, will depend to a large extent on the locality to be served and the distance such district is from a good and sufficient supply. Dr. Parkis, the eminent authority on the subject, has estimated that each individual requires 12 gallons of water per day, which allows $2\frac{1}{2}$ to 3 gallons for a sponge bath, but makes no allowance for water-closets. This same authority also states that if from

any cause the supply of water is limited, "that the minimum that ought to be allowed per head per day is four gallons." This, however, does not allow of proper cleanliness. As water is so important a necessity, it is desirable that from 20 to 30 gallons daily per head should be provided for all purpose. In practice, it will be found that 25 gallons is the general accepted quantity for each person per day.

Under the Regulations under the Dairies, Cowsheds, and Milk-shops Order it is stipulated that 12 gallons daily be provided for each cow. Horses are usually allowed more than this, the quantity generally provided being 16 gallons daily per horse.

Special Points to be noted regarding water.

1. Water presses equally in all directions.
2. The pressure of water is proportional to its depth.
3. Water presses ·433 lbs., or roughly $\frac{1}{2}$ lb., on every square inch per foot of head.
4. The pressure of a square foot of water with one foot of head (a cube) equals 62·35 lbs.

> *Note.*—"The head of pressure" or simply "head" at any point means the vertical distance of that point below the surface of the water, and is generally expressed in feet.

5. A cubic foot of water is said to weigh $62\frac{1}{4}$ lbs.
6. A cubic foot of water contains $6\frac{1}{4}$ gallons.
7. A gallon of water weighs 10 lbs. approximately.
8. There are 70,000 grains in a gallon of water.
9. Boiling point of water equals 212 degrees F.
10. Freezing point of water equals 32 degrees F.
11. Water expands $\frac{1}{25}$th of its bulk on being heated at its point of greatest density (39·2 degrees F.).

Calculations in regard to Water Supplies, etc.—While it is not altogether necessary to go into mathematics deeply regarding the subject of water supplies, some knowledge of a simple nature of calculations is, however, necessary in dealing with the matter, in order to compute the amount of water obtainable from any collecting area, or to estimate the space required for the storage of water, or again to find the pressure at certain points in pipes and mains, walls for damming water, etc.

There is nothing very serious in dealing with these problems; indeed they are simplicity itself, having regard to the fact that we have already covered all the necessary data.

Let us take a few typical examples of these simple problems, and by working them out arrive at their solution.

To compute the quantity of water to be obtained from a given collecting area one has to consider the average annual rainfall of the district together with the nature and size of the actual area itself.

If, for instance, the collecting area is moorland draining into a river, then allowance must be made for evaporation and percolation to deep strata, in addition to the water absorbed by plants and trees.

The usual practice is to allow one half of the average annual rainfall for surface soakage, evaporation, etc.

Now, if we want to find how many cubic feet of water could be obtained from any area which has an average annual rainfall of 36 inches and assuming the area itself to be 100 feet square, we first square the size of the area ; viz. :—

$100 \times 100 = 10{,}000$ square feet.

Now we take the rainfall and divide by 2 to allow for soakage, evaporation, etc. :—

$36 \div 2 = 18$ inches of rainfall, or $1{\cdot}5$ feet.

To get the cubic feet of water we expect, we now multiply the area by the last figures :—

$10{,}000 \times 1{\cdot}5 = 15{,}000$ cubic feet.

Should we wish to carry the calculation further and find the gallons which such an area would yield in the time mentioned—and knowing that a cubic foot of water contain $6\frac{1}{4}$ gallons—then the rest is a simple matter of multiplication thus :—

$15{,}000 \times 6{\cdot}25 = 93{,}750$ gallons of water.

From this, we can tell how much water may be allowed per head per day ; consequently it will readily be seen that this simple method of calculation is of great practical value.

When the collecting surface is of an impervious nature, as that of a roof or a bed of concrete, the allowance made for evaporation, etc., is so small that one can afford to neglect it altogether in any calculations. One will readily understand that in such cases the area is very small and the water immediately on falling runs off to storage, so that no time is allowed for evaporation, while, being an impervious area, surface soakage cannot take place.

Example.—How many gallons of water would be obtainable from a slightly sloping cement roof, 50 feet long and 30 feet broad, the average annual rainfall of the district being 30 inches, and how many people would it serve if we allow 15 gallons daily per head ?

Answer.

50×30=1500 square feet, area of roof.
1500×2·5=37,~~500~~ 50·0 cubic feet.
37,~~500~~ 50·0×6·25=234,375 gallons of water per year.
234,375÷365 (days in year) =642 gallons per day.
642÷15 (day's allowance)=~~43~~ 42 persons.

From this, it will be seen that with the allowance given of 15 gallons per day 43 persons could be supplied. Also note the important point that the first quantity of gallons arrived at in the calculation are for a year and in this case require to be reduced to a day's supply.

In order to find the quantity of water in a circular chamber or reservoir, we must square the diameter and multiply by the depth of the chamber to get the cubic capacity, then convert to gallons multiplying by 4·9. All calculations are of course in feet.

Example.—How many gallons of water could be stored in a circular chamber 20 feet in diameter and 15 feet deep, the water not being allowed to stand higher than 3 feet from the top of the chamber ?

Answer.

20×20=400 square feet, area.
400×12 (15−3)=4800 cubic feet.
4,800×4·9=23,520 gallons which could be stored.

N.B.—It will be observed that the usual method of finding the area of a circle, namely, by squaring the diameter and multiplying the result by ·7854 is in this case departed from. This 4·9 rule of course is only applicable to circular chambers, tanks, reservoirs, etc., and makes such calculations very simple indeed.

The methods of calculations shown may be applied in a great variety of ways according to the type of problem presenting itself, but they are all easy of solution, the principle in each being practically the same, whether the question is one of storage, collection, or estimating of water supplies. The great thing is to remember what relation a cubic foot of water has to a certain number of gallons and the other little points which have already been dealt with.

To take another example, if we know that a certain area be available for erecting a reservoir and we are required to find the necessary depth to store a given quantity of water, the following simple problem and solution will show how it is done.

Question.—What depth will a reservoir 20 feet long and 10 feet wide require to be to hold 20,000 gallons of water ?

Answer—

$20{,}000 \div 6{\cdot}25 = 3200$ cubic capacity required.
$20 \times 10 = 200$ feet, area provided.
$3200 \div 200 = 16$ feet, depth of reservoir.

Another method of the application of these simple formulæ is as follows :—

Question.—If the pressure at the foot of an upright water pipe, circular, 6 inches in diameter, is 49 lbs., what is the "head of pressure" of water inside the pipe?

Answer—

$6 \times 6 = 36$ inches.
$36 \times {\cdot}7854 = 28{\cdot}274$ inches (area at bottom of pipe).
$28{\cdot}274 \times {\cdot}433$ (pressure of 1 square inch of water)
$= 12{\cdot}242$ or roughly $12\frac{1}{4}$ lbs.
$49 \div 12{\cdot}25 = 4$ feet of head of pressure in pipe.

Another type of question one may meet with is this :—

Question.—A circular, 5 feet diameter well contains 1000 gallons of water. What is the depth and weight of water in the well?

Answer.—To find depth of well :—

$1000 \div 6{\cdot}25 = 160$ cubic feet.
$5 \times 5 \times {\cdot}7854 = 19{\cdot}63$ feet, area of well.
$160 \div 19{\cdot}63 = 8$ feet fully, depth of well.

To find weight of water :—

$19{\cdot}63 \times 62{\cdot}35$ (lbs. of pressure per square foot)
$= 1224{\cdot}5$ lbs. pressure per 1 foot of head.
$1224{\cdot}5 \times 8$ (depth of well)
$= {\cdot}9796$ lbs. or 4 tons 7 cwts. 1 qr. 24 lbs. pressure at foot of well.

A further example of these problems will be of express service to the student.

Question.—A reservoir has an area of 10 feet by 10 feet at the bottom, and it is 10 feet deep; the sides slope outwards at an angle of 45 degrees. What is the area at the top and how many gallons would such a reservoir hold?

Now, in dealing with this type of question, it is always a good plan to make a rough sketch of the subject and thus simplify the working of the problem. Let us then make the sketch as Fig. 15.

We know that the length and breadth of base being equal form a square, and the depth being the same as the base measurements we have a cube, but the sides slope outwards at an angle of 45 degrees; and we also know that 45 degrees is half of a right

angle, and that being the case a line drawn upwards from the base at the angle given will bisect an imaginary parallel line at a point equal in perpendicular height to the length of the base, and at exactly the same distance from the imaginary perpendicular line *AB* as the line *BC*.

The reason for this being that the angle of 45 degrees causes the line *BD* to fall within a square diagonally, and as this reservoir is square in all respects except for its sloping walls the distance *AD* will be 10 feet.

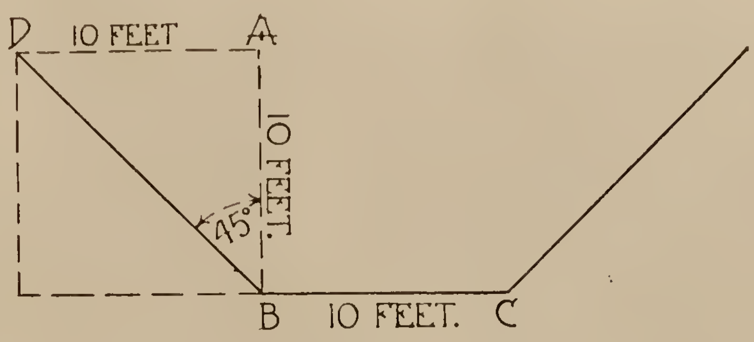


Fig. 15

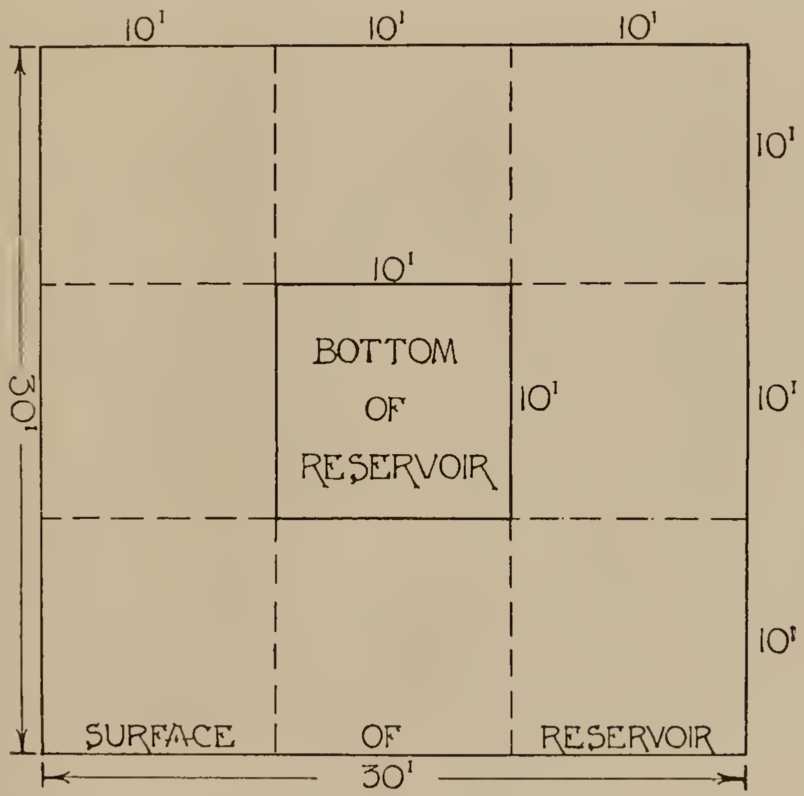


Fig. 16

On examining the second sketch in Fig. 16, which is a plan of the reservoir, we see that the sides at the surface measure each 30 feet.

Hence the answer becomes :—

$10 \times 10 = 100$ feet, area of base.
$30 \times 30 = 900$ feet, area of surface.
$900 + 100 = 1000$, $1000 \div 2 = 500$ mean area.
$500 \times 10 = 5000$ cubic capacity of reservoir.
$5000 \times 6{\cdot}25 = 31{,}250$ gallons which reservoir could hold.

Chapter III

THE LAWS GOVERNING WATER SUPPLIES

Law relating to Water Supply: England and Wales.—Under the Public Health Act, 1875, in sections 51 to 61, powers are given to provide water supplies, fix restrictions, construction of reservoirs, the carrying of mains, nature of supply, charges by water rates and by meter, etc., to Local Authorities, Urban and Rural. These sections, while important enough in their own way, do not call for any special comment here.

Section 62.—This very important section requires careful study, and is worth quoting at length:—"Where, on the report of the surveyor of a Local Authority, it appears to such Authority that any house within their district is without a proper water supply, and that such a supply of water can be furnished thereto at a cost not exceeding the water rate authorised by any local Act in force within the district, or where there is not any local Act so in force, at a cost not exceeding twopence per week or at such other cost as the Local Government Board may, on the application of the Local Authority, determine under all the circumstances of the case to be reasonable, the Local Authority shall give notice in writing to the owner, requiring him, within a time therein specified, to obtain such supply, and to do all such works as may be necessary for that purpose. If such notice is not complied with within the time specified the Local Authority may, if they think fit, do such works and obtain such supply, and for that purpose may enter into any contract with any water company supplying water within their district, and water rates may be made out and levied on the premises by the authority or company which furnishes the supply and may be recovered as if the owner or occupier of the premises had demanded a supply of water and was willing to pay water rates for the same, and any expenses incurred by the Local Authority in doing any such works may be recovered in a summary manner from the owner of the premises, or may by order of the Local Authority be declared to be private improvement expenses." From this section, it is important to note that action can only be taken on the report of the surveyor, consequently when the sanitary

inspector or inspector of nuisances finds a case of a house or premises without a proper water supply, it is his duty to report the matter to the surveyor of the district so that he may take action. The section quoted affects both Rural and Urban Authorities and districts, and one very often finds the offices of surveyor and inspector of nuisances combined in rural districts, so that in such cases the reports can be made directly the want of water is discovered. The point worthy of special note is that difference of opinion seems to prevail as to the exact meaning of the section with regard to a proper supply of water, one section contending that it refers to the *quality* of the water, while another section maintains that it is the *quantity* of water that is referred to.

Section 68 *P.H.A.* deals with the penalty for causing water to be corrupted by gas washings being allowed to flow into any stream, reservoir, aqueduct, pond or place for water.

Section 69 *P.H.A.* gives the power to a Local Authority for the taking of proceedings against the polluting of streams. These two sections do not call for further analysis here other than to note their importance, and the powers conveyed by them.

Section 70 *P.H.A.*—As this is a very important section in connection with rural, and occasionally urban water supplies, we will take it in full :—" On the representation of any person to any Local Authority that within their district the water in any well, tank or cistern, public or private, or supplied from any public pump, and used or likely to be used by man for drinking or domestic purposes, or for manufacturing drinks for the use of man, is so polluted as to be injurious to health, such Authority may apply to a court of summary jurisdiction for an order to remedy the same ; and thereupon such court shall summon the owner or occupier of the premises to which the well, tank or cistern belongs, if it be private, and in the case of a public well, tank, cistern or pump, any person alleged in the application to be interested in the same, and may either dismiss the application, or may make an order directing the well, tank, cistern or pump to be temporarily or permanently closed, or the water to be used for certain purposes only, or such other order as may appear to them to be requisite to prevent injury to the health of persons drinking the water. The court may, on the application of the Local Authority, authorise them to do whatever may be necessary in the execution of the order, and any expenses incurred by them may be recovered in a summary manner from the person on whom the order is made. Expenses incurred by any Rural Authority in the execution of this section, and not recovered by them as aforesaid, shall be special expenses." Let us now consider the more important points of this section. In the first place, it will be observed that the complainer may be " any

person," so that it does not necessarily mean that the person lodging a complaint or making a representation need be an official of the Authority. Next, it should be noted that the water must be injurious to health; the question of being dangerous is not mentioned in the section, so that in any case it is necessary to prove injury, as in a case tried some years ago it was held by the magistrates that injurious cannot be held to be synonymous with dangerous. Again it should be noted what powers are conferred on the court conducting an inquiry into a case under this section, and the important point should not be overlooked that the Local Authority may themselves do the work specified in the order of the court if the responsible person or persons fail to execute the order, and that any expenses thus incurred are recoverable. In conclusion, it will be observed that this section does not provide for a supply of water in the place of a well or pump that may be closed by order, but under these circumstances Section 62 would become operative.

Public Health Water Act, 1878: *Section* 3.—This section lays the duty of seeing that every occupied dwelling-house within their district has within a reasonable distance an available supply of wholesome water, sufficient for the consumption and use for domestic purposes of the inmates of the house, on the Rural Sanitary Authority. And when it appears to such an Authority, on the report of their inspector of nuisances or medical officer of health, that any occupied dwelling-house within their district is not so provided, and the authority is of the opinion that such a supply can be provided at a reasonable cost, not exceeding a capital sum on the rate of 5 per cent. per annum, and that the expense of providing the supply ought to be paid by the owner of the property, or defrayed as private improvement expenses, proceedings may be taken as follows:—

1. Authority may serve notice on owner to provide supply within six months of service of notice.
2. If work is not done within time specified, authority to serve a second notice, informing him if the requirements of first notice are not complied with within one month of date of second notice, the authority will provide the supply, the expense to be payable either by the owner or as a private improvement expense.
3. At the expiration of one month after service of second notice, if the work is not completed, the authority may provide the supply, and enter any premises and execute such works as are necessary.

(Power of entry as in section 102 and 103 P.H.A., 1875.)

4. Expenses of Authority may be recovered in a summary manner, or may be deemed private improvement expenses.
5. Where there are two or more owners of houses concerned, notices shall be served on each, and Authority may provide a joint supply and apportion the cost as they deem just.

Little comment need be made in connection with the foregoing provisions. Powers of entry for the Local Authority and their officials are given and means provided to relieve the Authority of any difficulty, financial or otherwise, which may be advanced by the owner of a house requiring a supply of water.

Section 8.—In this section of the Act, the duty of Rural Authorities and their officials, or any person authorised by them in writing, as regards periodical inspection of the water supply of their district is plainly laid down, and the same power of entry to premises is conferred as in the preceding section.

Local Government Act, 1894: *Section* 8, *subsection* (*e*).—Powers are given under this section to a Parish Council "to utilise any well, spring, or stream within their parish and provide facilities for obtaining water therefrom, but so as not to interfere with the rights of any corporation or person" and,

> subsection (*i*), "execute any works (including works of maintenance and improvement) incidental to or consequential on the exercise of their powers."

It need only be mentioned that this section does not relieve any District Council from their obligation with respect to water supply.

Law relating to Water Supply in Scotland.—The laws in Scotland governing water supplies differ very little in substance with those operating in England and Wales, but it is necessary that we should be conversant with those Acts which give the necessary powers for dealing with this question. First, let us consider the powers given in the Burgh Police (Scotland) Act, 1892, which we may do briefly, as the principal authority is found in the various sections of the Public Health (Scotland) Act, 1897.

Burgh Police (Scotland) Act, 1892.—*Sections* 257 *to* 269 of this Act deal with the power of Commissioners to construct public cisterns and pumps for the supply of water to baths and washhouses and the giving of powers for contracting for such supplies, fixing the price to be paid for same in any case under dispute, also the fixing of firecocks on pipes of water companies, the providing of sufficient supplies of water, and the erection of waterworks.

Burghs with less than 5000 inhabitants may obtain compulsory powers from the Sheriff of the district for providing water supplies.

This Act also makes it the duty of the owners of houses or premises to lay and fix the service pipes.

Under section 264 water is to be used for domestic purposes only, unless by agreement with the Commissioners.

The Act also makes provision for the erection and maintenance of drinking fountains, while the making of bye-laws with regard to water supplies is also provided for.

We now come to the principal Act in Scotland with regard to the provision of water supplies.

Public Health (Scotland) Act, 1897.—*Section* 124 deals with the supply of water for burghs.

Section 125.—By this section Local Authorities may require the owner of any occupied house which is without a proper supply of wholesome water at or reasonably near the said house, to provide such a supply, and do all the necessary works for that purpose.

Should the owner of such house fail to comply with the terms of the notice or order within twelve months of the service of such notice, the Local Authority may themselves provide a proper and sufficient supply.

Under this Act, the definition of the word "house" is of considerable importance, and is given as follows (*vide* section 3):—

"The word 'house' means a dwelling house and includes schools, also factories and other buildings in which persons are employed."

As to the distance between the house and the water supply that will meet the terms of the section as regards being "a reasonable distance," regard must be had to circumstances; cases of dispute under this head will be settled by the Sheriff. Local Authorities are not bound to recover the whole of the expenses incurred from the owner, as they may deem it reasonable to charge part of the expense against the rates of the district.

In apportioning expense, where there is more than one owner affected, rental will probably be regarded as the principal factor in the case.

Section 126, *subsection* 1.—Under this section powers are given to Local Authorities other than burghs to acquire, provide, or arrange for a supply of water for domestic use of the inhabitants of the burgh, and for sanitary and other purposes, and for that purpose they may acquire and conduct water from any lake, river, spring or stream, and may dig wells, make and maintain reservoirs, and do all necessary works to provide a sufficient and proper water supply; or they may contract with any waterwork company for the supply of water.

A provision is also laid down in this section, that where any company or authority is authorised by a Provisional Order to supply water in the district, the Local Authority shall take no action unless they shall previously have purchased or acquired the undertaking of such authority or company.

By subsection 2 of this section, Local Authorities may supply any surplus water to any public baths or washhouses or for trading purposes, but this can only be done after a full supply for domestic purposes is provided.

Section 127 P.H. (Scotland) Act, 1897.—This section imposes a penalty on any person or persons engaged in the manufacture of gas, naphtha, vitriol, paraffin, dyestuffs, or other deleterious substance, who shall pollute any stream, reservoir, aqueduct, well, pond, or place for water intended for domestic purposes, by any product, washing, or any other substance produced in any such manufacture.

Proceedings under this head must be taken within six months of the date of offence.

Section 130 P.H. (Scotland) Act, 1897.—With the sanction of the Local Government Board, this section empowers two or more Local Authorities to combine for the purpose of executing or acquiring an interest in or maintaining any works in regard to a proper water supply, which are by this Act or any other Act authorised for that purpose.

As it is not advisable to try to memorise too much in connection with the legal aspect of any subject, we have merely dealt with the main Acts, and sections of the Acts, from which we get our "authority." To the student intending to sit for the Certificate of the Royal Sanitary Institute (London) examination, the law as regards Scotland is superfluous, while to the student who intends to sit for the Sanitary Association of Scotland examination, that part of the law subjects applying to Scotland need only be studied.

Whatever field the student is following, it is essential that he should memorise the full proper names of the Acts he is studying, together with their true date.

The student may feel that a study of the Act itself might be of assistance to him or her, and such a course is not to be discouraged, but reading up an Act of Parliament apart from study is a very dry and discouraging matter, and for that reason the writer has endeavoured to present the text in as palatable a manner as possible, "boiling" the subject down, and giving the Acts, sections, and subsections together with comments which the student of Sanitary Science and Law must know thoroughly in order to answer properly any questions put to him, either in writing or orally at an examination.

Chapter IV

AIR

As water is a prime necessity of life, so is pure air a supreme facto. to good health. One would think from daily observation that the foregoing fact was but little known by the public at large, but recent legislation and education are gradually enlightening those who previously never gave much thought to this important subject. Unfortunately one finds it difficult to convince some people of the importance of open windows, and as a consequence the air in many houses may be highly polluted and yet there is nothing to indicate that such is the case, except perhaps a stuffiness. Certainly many people will, if they stop to think, have their suspicions as to the quality of the atmosphere of a room aroused by suffering from headaches, etc., but there are many who possess the faculty of breathing vitiated air without suffering any such signs. "Familiarity breeds contempt" is an old "saw," which is amply exemplified in cases of this sort by the fact that in houses where the atmosphere may be bad enough to smart the nostrils of the casual visitors, the inmates never seem to notice anything wrong, nor even if asked do they seem to notice any unusual odour.

It is a deplorable fact that in many of our really good working-class houses, the rooms are to all intents and purposes hermetically sealed, the windows kept always closed, while felt and other contrivances are used around doors and wherever air may get an inlet.

In some cases this may be due to laziness or ignorance on the part of the inmates, but in other cases the value of open windows, from a health point of view, is sacrificed on the altar of super-cleanliness of the industrious housewife in her endeavours to exclude all dirt and dust from the outside in summer time, and maintain a warmer temperature in winter time.

As already stated, it would appear that to many people the great value of fresh air is unknown. Let us then briefly consider the question of AIR AND THE RESPIRATORY SYSTEM. It has been calculated that an adult person inhales on an average 33·2 cubic feet of air per hour while at work, and half that volume (16·6 cubic feet) while at rest. This air by inhalation passes through

the nostrils, down the epiglottis into the larynx, thence down the thorax or windpipe and by way of the bronchi to the microscopical cells of the lungs, where it performs the function for which nature intends it. These small air cells of the lungs are surrounded by numerous blood-vessels containing part of the blood circulating through the body. Here the inhaled air gives off the oxygen it contains, and in return receives the various effete matters and moisture which the blood contains, and this is discharged into the atmosphere by the process of exhalation.

From this elementary description of the respiratory system in the human body, one will readily understand how essential it is to good health that fresh air be breathed, and also how vitiated atmospheres can produce so dire results in respiratory diseases and ailments.

It is therefore very important that the air we breathe should be, as far as possible, fresh and pure. We can select our food and water which may be brought long distances before they reach the consumer, but we must of necessity breathe the air around us, so that it is essential that we should never live, work, or sleep in close, impure or unventilated rooms, for if we do we can never be healthy owing to the want of pure air. It is for this reason that legislation has been introduced at various times with regard to housing, air space, and ventilation. Neither must it be forgotten that respiration takes place, to a certain extent, through the pores of the skin.

The amount is certainly very small in persons in normal health, but in the case of persons ailing—and more especially those suffering from any affection of the lungs—the amount is indeed very considerable. Let us now pass on to a study of air and ventilation from the point of view of health and sanitation.

The atmosphere or air is the vapour or gaseous covering of the globe on which we live, and all life depends on this air, which extends everywhere to a height of 40 miles. The pressure of this enormous mass of vapour is very great, and is equal to 15 lbs. of pressure on every square inch of surface. As will be readily understood, the **Composition of the Atmosphere** varies according to the different localities, their relative positions above sea level, their distance from the sea, and their position north or south of the equator. Dr. Parkes, in his researches, has given the following composition of an average sample of the atmosphere in the British Isles :—

Oxygen	209·6 per 1000 volumes.
Nitrogen	790·0 ,, ,,
Carbonic Acid	000·4 ,, ,,

Watery Vapour	varies with temperature.
Ammonia	variable.
Organic Matter (in vapour or suspended, dead or living)	,,
Ozone	,,
Salts of Sodium	,,
Other mineral substances . .	,,

It will not be out of place here to consider briefly these various constituents of the atmosphere so that we may the better appreciate their full significance in dealing with the subject.

Oxygen.—A colourless, tasteless, odourless gas, the most widely diffused of all elements. This important element varies very little in any sample of air which may be taken for analysis. It has been proved to be present to the extent of 20·98 per cent. of a sample taken from the open country atmosphere of a moorland, while in a sample taken from a badly ventilated room, the percentage was found to be 20·87. The difference, however, lies in the fact that, while both samples contain practically the same percentage, the oxygen in the town air is much inferior in quality, being greatly devitalised. It is to oxygen that the air owes its purifying power. It is the great supporter of combustion, and without it life would be impossible. At high altitudes such as mountain tops, the quantity of oxygen in the air is less than at lower levels, owing to lack of vegetation.

Ozone is a more active form of oxygen possessing similar properties. It is rarely found in congested areas and towns, except for a brief space following a thunderstorm, when the air is ozonised by electricity. As a rule, it is only to be found in the purest atmospheres, chiefly along the sea coast, where it is formed by electricity and the action of seawater and seaweed. There is most ozone in the air under the following conditions, viz. :—At night, on elevations or fairly high altitudes, in the winter time, around the coast, in rural districts with westerly breezes, and after thunderstorms.

Nitrogen is an inert gas which plays an important part in the composition of the air, where it assists in diluting the oxygen to the necessary strength required, oxygen being in itself much too potent without dilution. Nitrogen is very essential to all life when in combination with other gases, although—should it be present in excess of its proper proportion—it would extinguish a burning light.

Carbonic Acid Gas.—This gas (carbon dioxide) varies in proportion according to where a sample of air may be taken. To give it its chemical formulæ, CO_2 is given off in the process of

respiration when the oxygen in the air we breathe into the lungs is imparted to the small blood cells, carbonic acid gas is given off in exchange. In a sample of ordinary air we have seen that there is CO_2 present to the extent of ·4 per 1000 volumes, but of course in congested areas, or badly ventilated rooms, a very much larger quantity may be present in the air. It is a fact that this gas may be present in considerable quantities without those breathing such air feeling any immediate bad effects. The reason why this gas is looked upon as being so dangerous, is that when it is breathed out of the lungs it carries with it **organic particles** and watery vapour, the former of which is far more injurious than the CO_2 itself; for while the latter can be fairly easily removed, as it diffuses readily, the organic particles, which are not a gas, have a tendency to adhere to clothing, furniture, walls of rooms, etc. CO_2 is a narcotic, and produces deep sleep—one of the arguments of the ignorant against fresh air.

Organic Matter has been proved by experiment to be present in air in a quantity corresponding with the volume of CO_2 in the same sample, and it is for this reason that CO_2 is taken in fixing the standard of purity in the air. This organic matter is the result of tissue waste from the lungs and skin, and as such a large measure of injury may be attributed to it.

Watery Vapour is found in all atmospheres except in desert air during the dry season, and is also a source of injury as well as contamination. As already pointed out, it is given off by the skin and lungs in the process of respiration, and while under certain circumstances it may be dangerous, yet under proper conditions it is necessary to life.

Ammonia is a gas which arises from all decaying matter. It is seldom present in any appreciable quantity, and is removed from external air by rain.

As every one knows, there is a considerable amount of **Impurities in Air,** and in order to deal with them properly we will group them in three distinct classes, viz.:—1st, Gases; 2nd, Organic Particles; and 3rd, Inorganic Particles. We will consider these in the order given.

First, gaseous impurity may arise from ammonia, excess of CO_2, carbonic oxide, nitrous oxide, sulphuretted hydrogen, marsh gas, and sulphuric acid.

As we have already dealt with ammonia and CO_2, we will now briefly consider the other gases which pollute the air.

The gas known as **Carbonic Oxide** generally arises from over-heated cast-iron stoves or from charcoal stoves, and also from unburnt gas. It is a far more deadly product than CO_2, but is fortunately much rarer. Should this gas be present in the same

strength as CO_2 in the atmosphere, it would prove fatal to all inhaling it.

Nitrous Oxide is an offensive and injurious gas given off by decomposing animal matter, while **Marsh Gas** is generated in the watery marshes and swampy areas, and also in districts which are low-lying and where periodical flooding occurs. Marshes are the favourite breeding grounds of many insects, whilst, as is generally known, malaria germs have their place of origin there as a rule. Fortunately marsh gas in this country is practically harmless.

Sulphuretted Hydrogen is really a sewer gas created through the chemical action of the mixture of various liquid elements in the sewers, while **sulphurous acid** is due to the combustion of coal, etc., where the atmosphere is close.

Second impurity of air. **Organic Particles** include skin cells, pus cells, bites of insects, germs of all sorts, pollen from flowers, etc. These skin and pus cells are very numerous indeed, as every living creature by the act of respiration is continually discharging them into the air. Some of these organic particles are indeed very harmful, while others seem to have little, if any, effect on the human system.

The third impurity, **Inorganic Particles,** arises principally from trades or manufacturing process, although dust from roads etc., must be included in this category. Under this head we find metal contamination, such as lead, arsenic, zinc, copper, and brass, while we also find sand, chalk, phosphate of lime, etc. The impurities arising from certain trades are very injurious indeed, and special provisions are made for them, but many of the other impurities are harmful enough in themselves and can set up symptoms which prejudicate against good health.

When one considers all these impurities of the air, it will readily be understood why it is necessary that the question of purifying the atmosphere by making use of such agents as nature herself provides, assisted by some form of artificial aid where necessary, together with some form of ventilation and legislation, is imperative, more especially with regard to factories and workshops, housing, and places where people congregate indoors, such as theatres, cinemas, concert halls, etc. Remember, it is no uncommon thing to find very impure air in a cottage surrounded externally by an atmosphere of the finest quality. This may be due to structural defects such as the windows being much too small, or no provision made for the inlet of fresh air or the outlet of foul air, and the whole conditions made worse, if possible, by the ignorance of the occupants of the house.

It should also be borne in mind that *bad air, as a cause of disease,* demands the earnest attention of all engaged in matters

of public health. Besides the diseases which may be termed trade diseases, such as affect steel grinders, bakers, potters, and printers, one has to bear in mind that many of our germ-carried diseases are propagated by bad air, while impure air and badly ventilated workrooms, no less than houses themselves, play a large part in the spread of tuberculosis and respiratory diseases.

The air contains, as we know, ·4 per 1000 volumes of carbonic acid gas in an average sample; or, to express it in another way, there is ·4 cubic feet in every 1000 cubic feet of air. Now to arrive at the *Standard of Purity* which is set up, ·2 cubic feet of CO_2 in excess is allowed; thus we get a permissible total of ·6 cubic feet per 1000 cubic feet of air as the limit of impurity. Beyond this amount of CO_2 the air becomes fœtid and unwholesome, as the other impurities the air contains have increased in a ratio commensurate with the amount of CO_2 present.

Let us now consider what is the *quantity of air* requisite for people in order to ensure a proper supply of fresh air. The average person while at rest gives off ·6 cubic feet per hour—(males give off more, children less than this amount, which is an average)—and as we have seen that the air itself contains ·4 cubic feet per 1000 cubic feet, this gives us a total of 1 cubic foot of CO_2 in every 1000 cubic feet of air per hour.

In order, then, to keep within the standard of purity laid down, it is therefore essential that each person should be provided with 3000 cubic feet of air per hour. As this would entail either very large rooms in houses, or very vitiated atmosphere in ordinary sized rooms, a difficulty would arise in theory; but happily in practice the amount of air space for each person is regulated by the simple method of changing the air of the room as often as possible. Could this be done often enough without causing any discomfort, the air space would then not have that serious consideration which at all times it requires, since one has to contend with varying temperatures, with the velocity of the wind at various times and seasons, together with the draughts set up by the too violent movement of the air. It can easily be understood that cold air, travelling even at a slow rate, can not only be felt by the occupants of a room, but is also very disagreeable and capable of producing a good deal of discomfort, while warm air travelling fairly fast is never so unpleasant. Here, then, you have a great, though simple, fact in connection with changing the air of a room (which is ventilating it), and that is, wherever it is necessary to change the air often, do so by means of heated or warmed air, and you will have all round good results. It has been proved by experiment that in this country, taking the various seasons into consideration, together with general climatic conditions, the best that can be done

is a change in the air of a room three times in one hour. Now, having regard to the fact that the average person gives off ·6 cubic feet per hour of CO_2, and that the air itself contains ·4 cubic feet of CO_2, it follows that with a change of air three times per hour—and in order to keep within the standard of purity of ·6 cubic feet of CO_2 per 1000 cubic feet of air—each person should be provided with 1000 cubic feet of air space.

This, of course, is the ideal. In actual practice we find great differences of the amount of air space allowed. For instance, soldiers in peace time were allowed 600 cubic feet of air space per head. In common lodging-houses 300 cubic feet is allowed for each person, in factories and workshops the law demands 250 cubic feet per person for day work, and 400 cubic feet per head for night work—where the system of ventilation is good—while in cottages it is not unusual to find that the air space does not exceed 250 to 300 cubic feet for each person. In all our large towns the Local Authorities have set a standard which is usually laid down at 300 cubic feet of air space per person, and in many cases 400 cubic feet is insisted on. However, as we are now dealing more seriously with this and other important matters in sanitation, and as housing schemes are engaging the earnest attention of our foremost statesmen, physicians, social reformers, and sanitarians, something nearer the ideal may shortly be looked for.

To many first studying the important question of air space in rooms, there is often a *mistaken idea of the height of rooms*, and it comes as a shock to them to know that, beyond a certain point, height—from a ventilation point of view—is useless. The reason for this is that the respiratory impurities in the air tend to accumulate about the persons in the room, their clothing and the room furnishings, while it must not be forgotten that CO_2 being a heavy gas never rises to any great height ; indeed it is often found with the other impurities about the floor level of a room. This is one of the reasons why people sleep on bedsteads rather than on floor boards. CO_2 only leaves the lower position by the current of air caused when ventilation is introduced. Hence, when calculating air space, the height of a room beyond 12 feet is never taken into consideration. As proof of this statement regarding height and air space, it has been proved that the air of a space enclosed on each side by high walls, but not having a roof over it, will soon become foul, if the space be overcrowded.

From what we have learned of the composition of the atmosphere, its impurities, etc., it will easily be understood that even the external air is not always of the purest quality, while the air in our rooms requires to be changed at least three times per hour, and to do this some method of ventilation is necessary. A

person may enter a large room, seal up all windows, vents, and openings; but in one hour he will die from want of the pure air which is essential to sustain life. From this we learn that the size of a room is not what really matters, but the ventilation of the room, or the means by which the air is changed. In our next chapter we will study the various methods employed in this important science.

Chapter V

VENTILATION

By ventilation is meant the science of efficiently changing the air of a room or rooms without causing any draught or any sense of discomfort, and the dilution and removal of all impurities of a vitiated atmosphere; and here let it be said that it is a science of very great importance indeed as far as health is concerned, and its study has occupied the time and talents of some of our most eminent architects, engineers, and sanitarians. Ventilation may be taken under two distinct heads, namely:—Natural Ventilation and Artificial Ventilation.

In any system of ventilation it is always well to avail oneself of those agents or forces acting in nature which assist in the science, and which we may call the **Principles of Ventilation.** These agents or forces are:—1st, the action of the wind; 2nd, diffusion in the air itself; and 3rd, the movement in the air produced by the unequal weights of its various elements.

Taking the *wind as an aid to ventilation*, we find that this agent is made great use of in all systems of natural ventilation. This may be seen to good advantage in a room with windows on both sides, which when open allow a free cross current of air to play about the room.

In many of our hospitals and infirmaries this method is often employed either by itself or as an auxiliary of some form of artificial ventilation. The action of the wind is also used in another way, where the action of one body of air passing at right angles to another assists in ventilation by extraction. This is demonstrated in cowls, vanes, vent-tubes, or the ventilators on ships. Wind has one distinct disadvantage, however, as at one time it may be travelling too fast, while at another time it may be quite stagnant and therefore useless. For this reason, the wind has not been found to answer very well for house ventilation owing to the difficulty in regulating the amount introduced.

As the name implies, *Diffusion* is the property which gases of different densities possess of mixing with one another.

It assists, in a small way, in the ventilation of rooms, and may

take place through anything porous, such as curtains, open partitions, etc. It is, however, very slow in its action and consequently of little use in itself in purifying the atmosphere.

A very strong factor in the atmosphere and a very important one in natural ventilation is the *movement of unequal weights of air.* Air expands approximately one five-hundredth part of its volume for every degree of Fahrenheit. As the air expands, therefore the room cannot contain the whole of it, and the excess volume of air will find its exit by any openings that exist. Now, the outside air being colder and consequently heavier than the air inside the house, an inequality is established, and the law of gravitation will cause this cold or heavier air to enter the room by any openings that may be provided. It is on this active agency of the atmosphere that we base our methods of natural ventilation, such as we have in ventilation outlet and inlet vent-gratings, ventilating bricks, and similar apparatus, while it greatly assists and makes possible many forms of artificial ventilation.

Let us now consider some of the common forms of ventilation one meets with daily in houses, small halls, schools, etc.

Taking first the simplest method employed—*air inlets and outlets*—we find these consist of cast iron or galvanised iron gratings of a suitable size and sufficient number commensurate with the cubical capacity of the room. These gratings are fitted into openings left in the stone or brick work of the walls of the room, both externally and internally. The outlet gratings should have a slightly larger area than the inlet ones, owing of course to the outgoing air having increased in volume. Except for ventilation under floors, the inlet gratings need not necessarily be fixed low down near the floor; if they are, then during cold weather the fresh air on entering will be immediately felt and a good deal of discomfort experienced by those occupying the room. Inlets and outlets should never be placed close together, otherwise proper dilution of the atmosphere will not take place. Inlets should be placed say about six feet from the floor level, and outlets near the ceiling. With the inlets, some method should be employed whereby an upward direction is imparted to the incoming current of air. By having the inlets high up there is less likelihood of draughts being felt, while the cold air, being heavy, will descend on entering, and in descending it will be gradually warmed.

Very often in the building of houses, specially constructed bricks are used for ventilation purposes known as **Ellison's Ventilating Bricks.** These are made similar to ordinary bricks, but are perforated by a series of conical shaped openings running through them as shown in Fig. 17. They are built into the walls with the apex of the cone to the outside. In this way the air is so

admitted to the room that, by passing through the small opening of the cone and then through the gradually expanding aperture into the house. it minimises any possibilities of draughts.

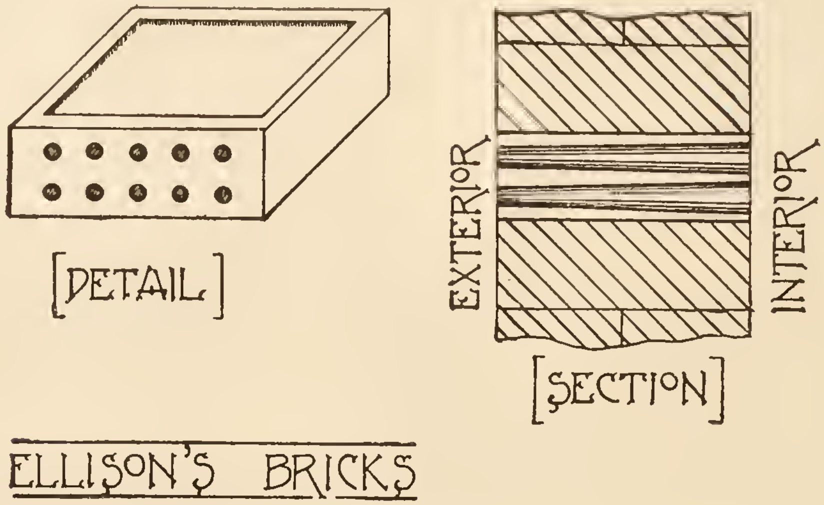


Fig. 17

What is known as the **Sheringham Valve** is shown in Fig. 18. This consists of a metal box built into the wall; the front of this box is hinged at the bottom, and it can be so adjusted as to regulate the amount of air it is desirable to admit. Now this is done by means of a balanced weight with string and pulley actuating the front flap of the box. The outer side of the box is finished with a grating through which the air enters, while the flap itself imparts the necessary upward direction to the incoming air.

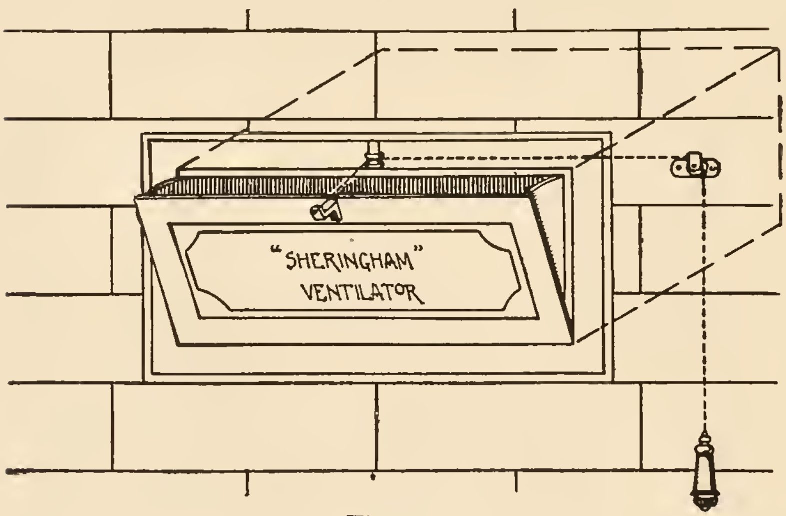


Fig. 18

Cowls are also much used for ventilating purposes, and these may be either fixed or movable, as shown in Fig. 19. We have first the fixed cowl; 2nd, the weather vane cowl; and 3rd, the revolving cowl. A form of cowl is used on all vents-tubes to check any tendency to downdraught, while they also increase the extracting power of the wind and keep out rain. A common type of roof ventilator is what is known as **M'Kinnell's Roof Ventilator,** fitted as shown in Fig. 20. It consists of two tubes, the inlet en-

circling the outlet tube, which is carried up some distance above the inlet and fitted with a cowl, the lower end being flanged and serving the purpose of diverting the incoming fresh air across the ceiling, from whence it descends, being warmed in the process. This form of ventilator is very suitable for single storey buildings, small halls or similar structures.

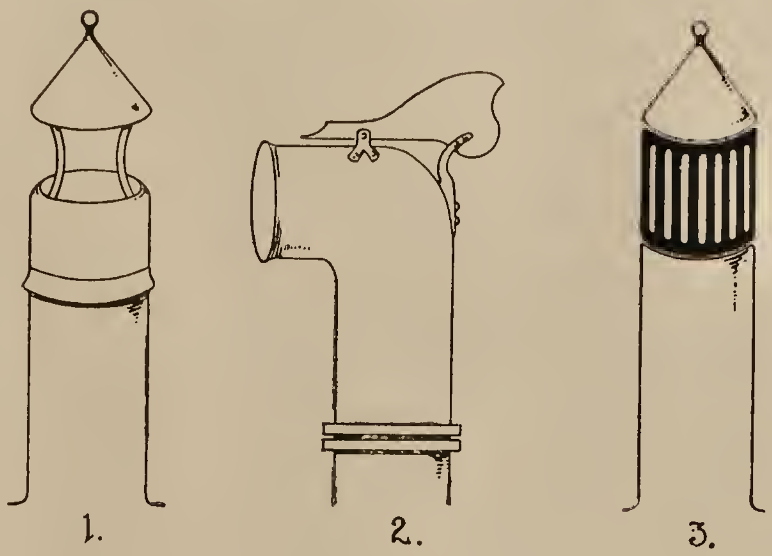


Fig. 19

Louvres are much used in connection with ventilation either in roofs, windows, or partitions. Roof louvres consist, as a rule, of a wood framework, built on the ridge of the roof, and having "slats" laid in at an angle as shown in Fig. 21. This type of ventilator is very popular in connection with cowsheds and stables. The other form of louvres may be fitted in windows, or partitions in offices and schoolrooms, etc. Such takes the place of one of the larger panes of glass, and consists, as shown in Fig. 22, of a series of glass strips fitted in a metal framework so made that the same can be tightly closed or opened to the necessary space to admit the quantity of air required.

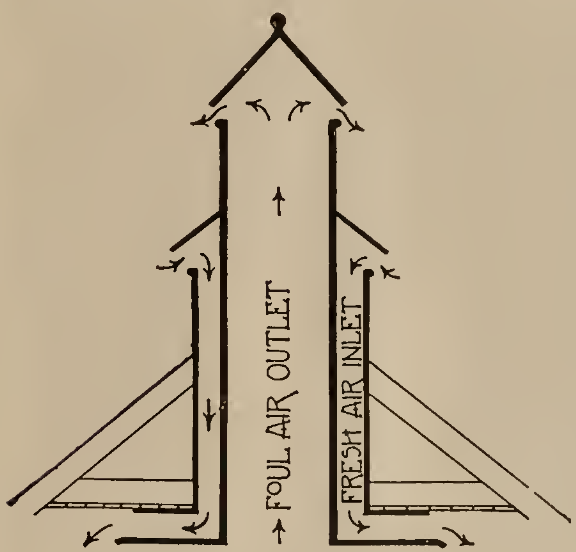


Fig. 20

Another type of window ventilator is what is termed the **Hinckes Bird Window Ventilator.** Sash windows are, of course, good ventilators, and are used as such in houses, sleeping dormitories, etc. The trouble with them, of course, is that if they are facing in the direction in which the wind is blowing, the incoming air, especially in the winter season, will prove rather un-

comfortable and will probably cause a draught in the room. For this reason, a patent device was produced known as the Hinckes Bird Ventilator, and, as will be seen from the sketch in Fig. 23, it consists simply of a bar of wood, or in some cases of plate glass, made the exact breadth of the window sash and from $3\frac{1}{2}$ to $4\frac{1}{2}$ inches deep. This bar is weather-grooved, and finished on the top to take the lower edge of the bottom sash, while it has its underside made to fit the sill of the window frame. In this way, a tight joint or joints are made between the sash and the bar. When in position, the bar raises the top rail of the lower sash the corresponding number of inches above the lower rail of the upper sash as the thickness of the bar itself, and thus we have a space created. It is at this point that the air enters, and, coming in contact with the upper glass and frame of the lower sash, an upward direction is imparted to it on entering the room, thus avoiding draughts.

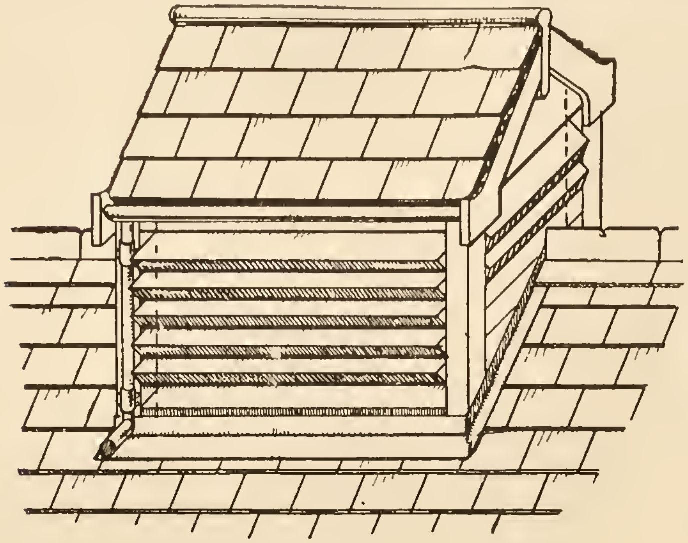


Fig. 21

A modification of this type of ventilator which may be met with has the bar hinged to the bottom rail of the window sash, so that the window may be closed when so desired with the minimum of trouble. It need only be added that these types of ventilators have much to commend them. Among their advantages are the

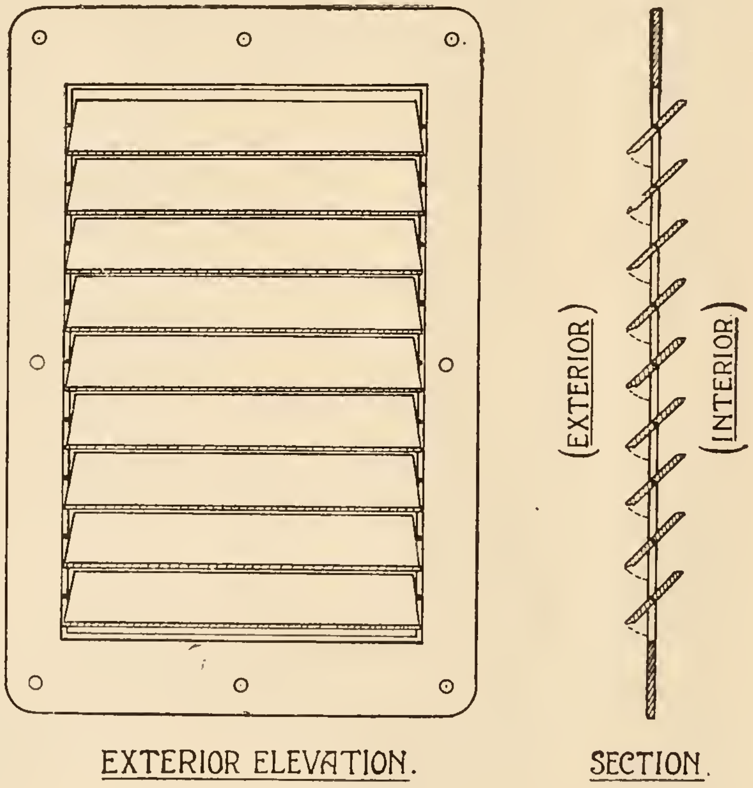


Fig. 22

following :—they are cheap, easy to work, they do away with the arguments of draughts from open windows, and are not unsightly.

One of the commonest types of ventilators to be met with in connection with schools and small halls is what is known as **Tobin's Tube,** illustrated in Fig. 24. The means of ventilation in this case consists of outlets either in or near the ceiling. The air enters through gratings, which may be either below or on the floor level in the outer walls of the building, and is conducted by the tube or

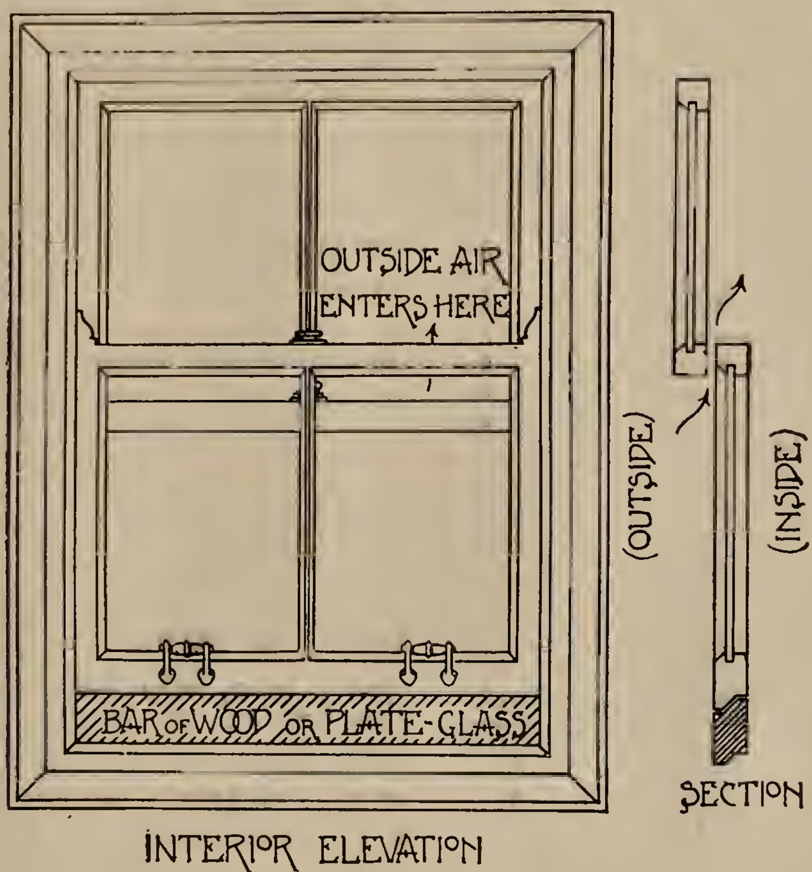


Fig. 23

tubes through and up the inside walls to a height of about 6 feet. These tubes are very simple in construction, being made of wood or, in some cases, metal. They, of course, vary in size, but the common measurements are about 12 inches broad and 9 inches deep. It is a mistake to carry them higher up the walls than 6 feet, as this height is sufficient to carry the air clear of the heads of any one in the room, while the action of the tubes sends the incoming air well up into the room. Again, if the tubes be carried too high, then the incoming air will probably be discharged over an outlet, and thus the purpose intended to be served would be defeated. In fixing these tubes, care must be taken to see that there are no projections such as shelves, etc., fitted immediately

above same. The tubes ought to be provided with means for regulating the amount of fresh air entering the room. This is very easily accomplished by means of a pivoted plate the size of each tube internally, which operates by a handle on the outside, by means of which the tube may be either closed, part open, or full open.

The **Chimney as a Ventilator** plays no mean part in carrying off vitiated air from our rooms. It is a powerful extractor of air, and consequently a good ventilator. Its action is greatly assisted by the fire in the grate, but, even independent of this source of help, it is a good ventilator.

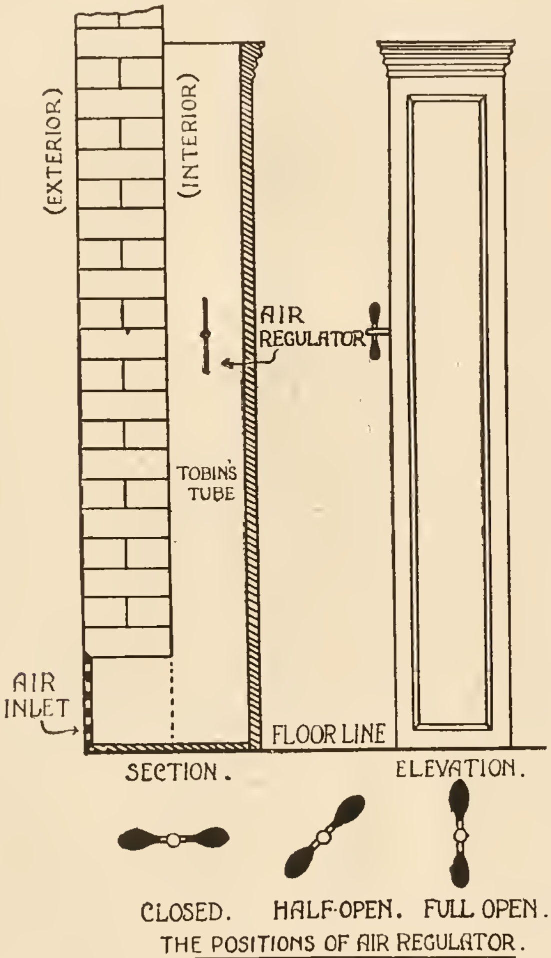


Fig. 24

Acting in conjunction with chimneys, various methods of ventilation are employed, foremost among which might be placed what is known as **Boyle's Mica Flap Ventilator,** defined in Fig. 25. This consists of a metal frame fitted into the wall of the room near the ceiling and communicating with the flue of the chimney. In this frame are fitted a number of mica or talc valves or flaps, set at such an angle that they allow the exit of the heated air of the room, but they immediately close on the least tendency to downdraught from the chimney, and thereby prevent the entry of smoke into the room by this source. In some small halls, one finds one of these mica flap ventilators fitted into each chimney, thus giving good and satisfactory results.

So far, we have considered what might easily be termed some of the types of natural ventilation, making use of the various wind agencies to aid in changing the air of a room. Taking the subject a step further, we find some simple methods employed in connection with artificial ventilation which allow us to apply various ordinary fittings in houses and halls to assist in the work.

Foremost among these may be taken the ordinary *fireplace.* In connection with the chimney, this common agency is of very

great importance from a ventilation point of view in extracting foul air from a room. The air of the apartment rushing towards the chimney may in some cases cause a draught, but this is, to some measure at least, eliminated by the heat of the fire and by regulating the entry of fresh air in such a way as to diffuse it as much as possible. Before we leave this subject, we will consider another everyday fitting which can be utilised for the purpose of ventilation, namely, *gas* pendants and brackets. Many forms of gas appliances are made which have a tube or tubes carried from the top through the ceiling and roof, thus acting as outlet for impure air.

A typical example of this system is what is known as "sunlights," or a series of burners, fitted together under one shade near the ceiling, to the top of which is fixed an outlet shaft. The heat generated by the lamps when lit causes a movement of air up this outlet tube, and this draws the foul air away from the room. It is a great pity that some form of legislation is not in force requiring all gas fittings to be connected to some ventilating shaft, and that for two good reasons, first to assist in the general scheme of ventilation of the room, and second, so that the impurity added to the air of the room by the combustion of the gas, while burning, would not only be carried off but would also assist in carrying off other impurities.

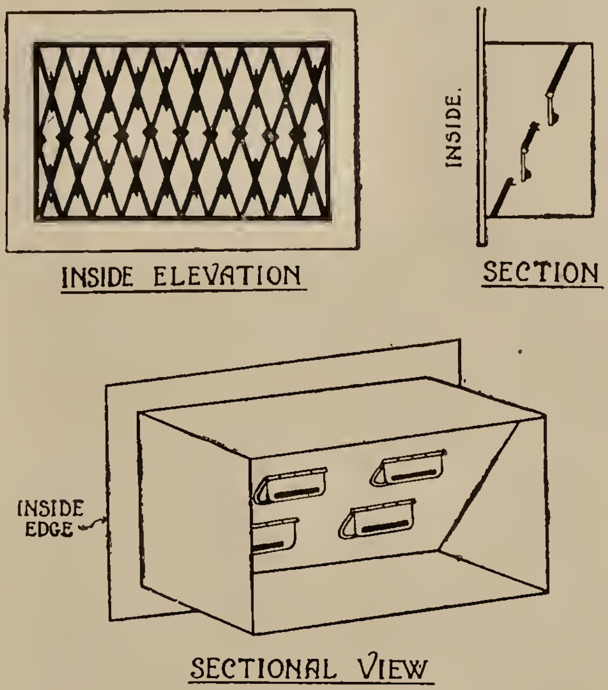


Fig. 25

Where electricity is used, or can be used, *fans* may be employed to assist in the work. These fans consist of a series of vanes fixed in an oblique fashion on a revolving axis which is driven by a motor connected to the electrical supply. Fans can be used either for propulsion or extraction, according to whether they are fitted to be used with either the inlet or outlet openings. By the rapid revolutions of the fan, a movement of air is set up which causes a steady current of air in the apartment wherein it is working. Fans are made in varying sizes consistent with the sizes of the rooms for which they are intended. Besides electricity as a driving force for fans, steam may be used, or a small gas engine employed. These fans are very clean in action, give little trouble,

and do not—in themselves—add to the impurity of the atmosphere, as does gas or even some forms of fireplaces.

Steam is sometimes used to assist in ventilation. The steam is discharged in jets into an outlet shaft, and sets up a movement of air which assists in carrying off the vitiated atmosphere.

Having dealt with what might be termed the methods of ventilation employed in houses, small halls, schoolrooms, etc., or places where the cubical contents are not very large, we will now consider some of the systems employed in dealing with the air of places with larger volumes of the atmosphere, where consequent impurities have to be dealt with.

It has been seen how various agencies in nature and in ordinary house and hall fittings can be used to assist in the great work of ventilation, but we will have observed also that one of the great drawbacks to any scheme has been the sense of discomfort caused, and which arises from the coldness of the incoming fresh air. It is due to this fact, to a considerable extent at least, that we cannot change the air of our rooms oftener than three times an hour, whereas in all large halls, large schools, theatres, cinemas, and places where large numbers of people congregate, the air requires to be changed at least ten times an hour. For this reason, means are employed of warming or heating the air before it enters the room for which it is intended. Heat is, of course, of great importance in any scheme of ventilation, and its importance from this part of the study calls for our earnest consideration. Heat being, as stated, of so great assistance in this work, it is therefore worth while noting that in its application to ventilation it may be used in three different ways, viz. :—by **Radiation,** where the heat travels by direct rays, by **Conduction,** where the heat passes from one particle of the atmosphere to another, and by **Convection,** which implies the conveyance of heat by moving masses of air. In radiation, the rays travel through the air without any appreciable loss of their power, and warm any conductor with which they come in contact, such as walls, floors, furniture, etc.

While this form of heat is preferable to the others, it has certain drawbacks. The commonest type of radiated heat indoors is by open fireplaces, and these are very extravagant in the use of fuel, and very rarely can one have a room uniformly warmed by them, whilst the air rushing from the inlets and distant parts of the room is liable to cause draughts. Specially constructed fireplaces are frequently to be met with which embody many principles to assist in good ventilation, a type of which is shown in Fig. 26.

In these firegrates as little iron is used in their construction as possible, tiled brick or fireclay brick being mostly used, while

the back of the grate, which is also of firebrick, is set with an inclination at the top toward the front of the fire. An adjustable metal regulator is fitted at the top of the grate over the fire.

By this method of construction, the smoke from the fire, and with it the heat, instead of passing backwards or directly up the chimney—as in the old type of grates—has a forward tendency imparted to it which adds greatly to the heat imparted to the air of the room. Other types have fresh-air inlets fitted at the side of the grate beside the fire itself, so that the incoming air may be warmed. Where fireplaces are to be used to assist in ventilation, they should be carried as far into the room as practicable in order to get the full advantage of radiation, while the space under the fire bars ought to be kept close, by means of a fairly tight-fitting ashpan front. Again, firebricks with as large a surface area as possible ought to be employed in the construction of all firegrates.

Fig. 26

Close or partially open *stoves* may also be used for this purpose. These have certain decided advantages over firegrates in that they may be constructed inside the room, and consequently with less loss of heat. The air, moreover, is more uniformly warmed than with a firegrate. Again, the air of the room, instead of being drawn quickly up the chimney, is warmed by coming in contact with the stove and ascends immediately. There are, however, certain disadvantages with regard to stoves which we must not lose sight of.

For example, we lose to a certain extent the value of the chimney as an outlet and extractor of foul air, while again, the air coming in contact with the whole exposed surface of the stove is apt to be scorched and rendered too dry, unless provision has been made against this contingency by placing a vessel containing water on or near the stove.

Then—and most important of all—we have seen that overheated metal gives off carbonic oxide, which is a very poisonous element in the air of a room.

Another form of heating which is very popular because of the cleanliness and economy with which they may be employed are *gas fires*. Where these are used for this purpose, it is very important to see that they are fitted with proper means of ventilation by a pipe carried outside, or where a gas fire is fitted in an existing firegrate, the vent-pipe should be carried into the chimney.

Gas Stoves and Radiators are also much employed for this purpose, and are constructed so as to warm the incoming air. With gas stoves, this is accomplished by the air being conducted through a tube which passes through a chamber where the gas is burning ; this chamber containing the gas burners is ventilated by a shaft to carry off the fumes of combustion. With radiators, which consist of a series of upright tubes containing water, and under which are a row of gas jets enclosed in the metal framework of the apparatus, the air of the room may be warmed without any connection with the incoming air. The general practice, however, is to place these radiators in front of the inlets for fresh air, and thus the air on entering is heated by passing over the warm surface of the radiator.

In large public buildings and schools, the rooms are often heated by *hot water or steam.* A boiler situated in the basement of the building, or some suitable annexe, supplies the steam or water which is carried throughout the building by means of pipes. These pipes are often fixed along the " skirting " of the wall and into the room, but they are sometimes let into the floor or the wall, an open iron grating enclosing them, and at the same time allowing the heat to enter the room. With this system, it frequently happens that in some of the rooms it is less necessary to have the heat so continuous as in others, and in a good system " shut down valves " are provided for each room.

In order to get the full advantage of such a system as this, radiators are introduced. These radiators give a large heating surface, and are fitted with a screw valve in order to regulate the quantity of steam or hot water entering them in accordance with the requirements of the room.

These radiators are made in two styles, one which deals simply with the steam or water passing through it and the air in the room, and the other which has an inlet tube attached to it so that the incoming air is warmed before it enters the room.

One other method in use in large halls, theatres, etc., and which is employed in our present House of Commons, is what is known as the **Hot-Air System.** In the accompanying diagram (see Fig. 27) an attempt is made to convey an idea of this system as found in operation in the Houses of Parliament.

No attempt is made in this sketch to give a true small-scale sectional elevation of the buildings, as we are not here concerned with the architectural details of the structure, but the student will find that the main idea is simply to present the system in a fashion which will be easily followed and understood. It is essential that this should be accomplished, as in all our largest buildings a similar system to this, or some modification of it, is being more generally

employed every day. Let us now proceed to a study of this system. The air which enters through the basement of the buildings passes through a filter composed of cotton-wool screens, and in cold weather it is then conducted over hot-water pipes.—(*N.B.*—In the heat of summer, the air at this stage is cooled by passing it over ice, or cold water, or brine pipes.)—This warm air is now conducted by shafts to a space immediately beneath the floor of the building. In the floor are iron gratings, through the openings of which the warm air passes to the House itself, where it rises to the ceiling, gaining an outlet through the open ornamental plaster work of the ceiling itself. Behind this plaster work is another space along which the air travels to a vertical air shaft which carries it to the foot of the clock tower, where a fire is kept burning. This fire is dependent for the air, for its combustion, from the atmosphere which is travelling along the shafts leading from the ceiling of the House, and so we see that the arrangement of the system is such that the vitiated air from the chamber is carried along without any trouble. After reaching the fire, the vitiated air is carried by the heat and smoke of the fire up the smoke shaft, and thus high up into the open air by way of an outlet on the clock tower.

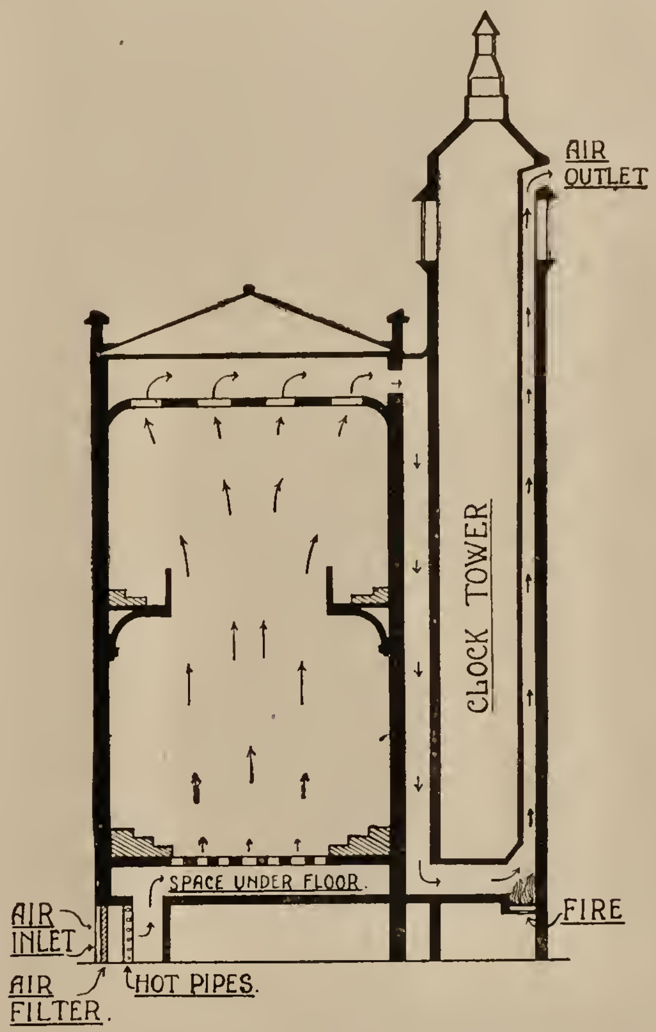


Fig. 27

Summary.—In closing this chapter, it will be well to briefly summarise some of the important points which we have just been studying. These we will set down in tabulated form, as follows:—

1. Pure air is essential for the health of the individual and the community.

2. The atmosphere contains, in an average sample, ·4 cubic feet of carbonic acid gas (CO_2) per 1000 cubic feet.
3. In the process of respiration, ·6 cubic feet of CO_2 per 1000 cubic feet of air is given off by an average person.
4. The standard of purity in the atmosphere with regard to CO_2 is ·6 cubic feet per 1000 cubic feet of air space.
5. It therefore follows that each person requires to be provided with 3000 cubic feet of air space, but as the air of a room is capable of being changed three times in one hour, then 1000 cubic feet of space ought to be provided for each person.
6. A similar amount of cubic space may be allowed for cattle owing to the greater liberties which may be taken with regard to animals.
7. Where it is necessary to change the air of a room oftener than three times an hour, as in theatres, etc., some form of artificial ventilation is necessary.
8. Ventilation, whether natural or artificial, is always essential in order to introduce pure air and carry off foul air and gases.
9. CO_2 is taken with regard to the standard of purity, as it has been proved to be present in the air to the same extent as more dangerous elements, and it lends itself to tests better.
10. The height of a room beyond 12 feet cannot be taken into account owing to the fact that certain of the atmospheric impurities adhere to persons, their clothing, and to room fixtures, etc. Therefore, in calculating cubic capacity, no account is taken as a rule of any ceiling beyond 12 feet in height for persons, or 16 feet in height for animals.
11. Outlet and inlet openings for ventilation ought to be provided in all buildings, with the outlets near the ceiling.
12. Owing to the expansion of heated air, the outlets ought to be more numerous than the inlets, and they ought to be placed well apart to assist diffusion.
13. Incoming air, to avoid causing draughts, ought to be conducted up the walls of a room to a height of 5 or 6 feet.
14. Inlet tubes ought to be as wide as possible, circular in shape, with air-tight joints, and as few angles in them as possible.
15. Downdraught from roof ventilators may be avoided by fixing a plate, larger in diameter than the shaft itself,

immediately underneath the ventilator and within a few inches of it.

16. The quantity of air entering rooms ought to be regulated in some manner so as to avoid draughts as far as possible.
17. Outlet shafts ought to be finished, each with a cowl, to prevent rain entering, or obstruction by birds' nests, etc.
18. Advantage ought to be taken of all ordinary everyday appliances, such as firegrates, gas fittings, windows, etc., to employ them to assist in any scheme of ventilation.
19. Owing to the coldness of incoming air being responsible for a great sense of discomfort, it is necessary—where large volumes of air have to be dealt with, and where it is necessary to change the air oftener than three times an hour—that all incoming air be warmed. For this purpose, fires, stoves, steam, hot-water pipes, and hot air may be employed.

Chapter VI

CALCULATION OF CUBIC SPACE

In dealing with the question of ventilation, whether in houses, workshops, or other places, some means of calculating the space available is necessary. It is the purpose, therefore, of this chapter to explain briefly how rooms of various shapes and designs may be calculated, with regard to their air space, with simplicity by using the following formulæ as a basis to work on.

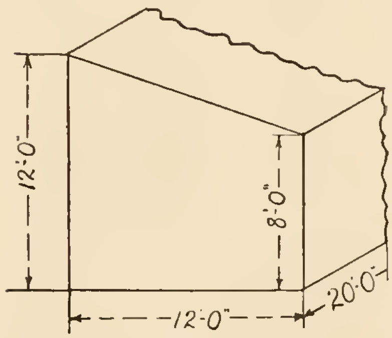


Fig. 28

We know that to get the cubic capacity of a regular-shaped room we have simply to multiply the length by the breadth and by the height, viz. :—

If a room is 15 feet long, 12 feet broad, and 10 feet high what are the cubic contents of the room ?

Answer—

15 feet (length) × 12 feet (breadth) = 180 square feet, area.
180 feet (area) × 10 feet (height) = 1800 cubic feet.

As, however, we often come across buildings of varying dimensions, as in Fig. 28, it stands to reason that we must have some other method of solving such a problem. Thus, in this case we take *the mean height*, that is, we add the two heights together and divide by 2, as follows :—

$$12' + 8' = 20' \div 2' = 10 \text{ feet mean height.}$$

The rest of the problem is now easy, and is simply

$$20' \times 12' = 240 \text{ feet, area.}$$
$$240' \times 10' = 2400 \text{ cubic feet.}$$

We will now consider a circular-shaped chamber, dealt with on the ·7854 rule, in which we square the diameter and multiply by ·7854, so as to obtain the area.

For Example.—A circular room is 12 feet in diameter and 9 feet high. What are its cubical contents?

Answer—

$12' \times 12' = 144'$.

$144' \times \cdot 7854 = 113$ square feet, area.

$113' \times 9' = \underline{1017 \text{ cubic feet (nearly)}}$.

Again, we may have a combination of rectangular buildings where one part has equal heights and an adjoining part has unequal heights as in Fig. 29. Here we have a building 30 feet long;

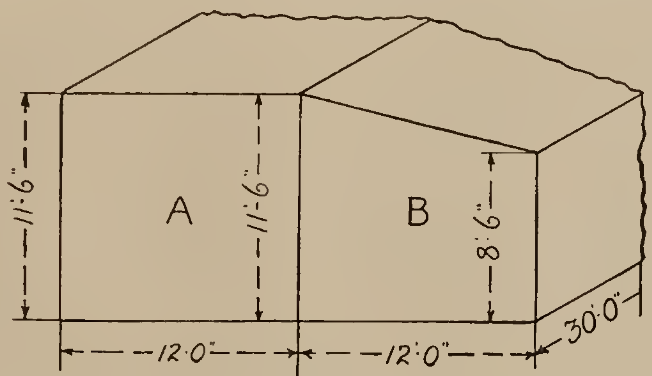


Fig. 29

its height at the lowest point is 8 feet 6 inches and at the highest point 11 feet 6 inches, the breadth of the rooms being 12 feet each.

In working out such a combination problem, the student will find it much easier if he "breaks" it up, as in this case, into two parts, and works it out individually, thus:—

Part A.

$30' \times 12' = 360$ feet, area;

$360' \times 11 \cdot 5' = 4140$ cubic feet.

Part B.

$30' \times 12' = 360$ feet, area.

$11 \cdot 5' + 8 \cdot 5' = 20'$.

$20' \div 2' = 10$ feet, mean height.

$360' \times 10' = 3600$ cubic feet.

Part A+Part B

$= 4140 + 3600 = \underline{7740 \text{ cubic feet.}}$ Total air space.

As it is much easier to work with decimals. We give here the value in decimals of each inch up to 1 foot, viz.:—

1 inch	= ·08.	7 inches	= ·58.
2 ,,	= ·17.	8 ,,	= ·67.
3 ,,	= ·25.	9 ,,	= ·75.
4 ,,	= ·33.	10 ,,	= ·83.
5 ,,	= ·42.	11 ,,	= ·92.
6 ,,	= ·5.	12 ,,	= 1.

Note particularly that 3, 6, and 9 inches equal ·25, ·5, and ·75 respectively.

Where measurements have to be taken in connection with a building which has the roof rising in triangular form, as in Fig. 30,

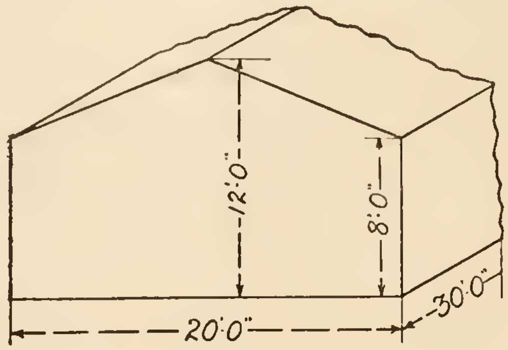


Fig. 30

the simplest method is to take the mean height and work with that as follows :—

For Example.—A room 30 feet long and 20 feet broad measures 12 feet to the apex of the ceiling, the walls being 8 feet high. What are the cubical contents of the room ?

Answer—

$20' \times 30' = 600$ feet, area.
$12' + 8' = 20$ feet.
$20' \div 2' = 10$ feet, mean height.
$600' \times 10' = 6000$ cubic feet in room.

Another method of dealing with triangular spaces in order to find the area is to multiply the base by half the height.

Using this method in the foregoing problem we get :—

$30' \times 20' = 600$ feet, area.
$600' \times 8' = 4800$ cubic feet in rectangular part.
$600' \times 2'$ (half the height) $= 1200$ cubic feet.
$4800 + 1200 = 6000$ cubic feet total capacity.

Where the measurements include *cones,* the formula to find cubic capacity is :—" Multiply the area of the base by one third the height of cone."

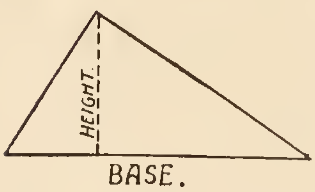


Fig. 31

This same formula also applies to *pyramids, i.e.* base multiplied by one-third the height; the difference of course being that, whereas in the pyramid the base is square, in the cone it is circular.

With a *dome* the formula is " the area of the base multiplied by two-thirds of the height."

When dealing with *elliptical* chambers, "multiply together the long and the short diameters and this result by ·7854." This will give the area, which can readily be converted into cubic feet by multiplying by the height. (See Fig. 32.)

Should any building to be measured have a part, probably the roof, in the form of a segment of a circle, the formula is :— "Add the cube of the height divided by twice the chord, to two-thirds of the product of chord and height." (See Fig. 33.) This may be expressed as follows :—

$$\frac{H^3}{2\ Ch.}+(\tfrac{2}{3}\text{ of Ch.}\times H)=\text{area of segment (nearly).}$$

Let us now take one or two examples, using the formulæ as given.

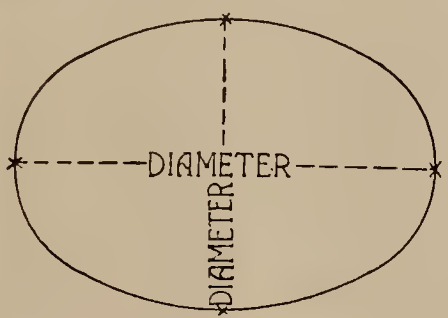


Fig. 32

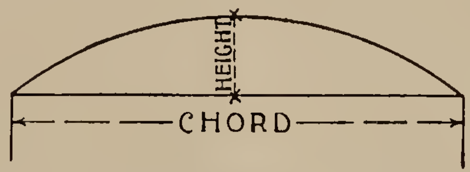


Fig. 33

Example 1.—What would be the cubic capacity of an attic apartment measuring 30 feet long and 25 feet wide, being 9 feet from floor to apex of roof ?

Answer—

30′×25′=750 square feet, area.
750′×4·5′ (half of 9 feet height)=<u>3375 cubic feet.</u>

Example 2.—What is the cubic capacity of a bell tent 12 feet from ground to apex and 12 feet in diameter ?

Answer—

12′×12′=144′.
144′×·7854′=113 square feet, area.
113′×3′ (one-third of height)=<u>339 cubic feet.</u>

Example 3.—What would be the capacity of a pyramid 12 feet high and 12 feet square at the base ?

Answer—

12′×12′=144 square feet, area.
144′×4′ (one-third of height)=<u>576 cubic feet.</u>

Example 4.—The dome of a building is 18 feet high from floor

to top, and has a diameter of 15 feet. What are the cubical contents of the dome?

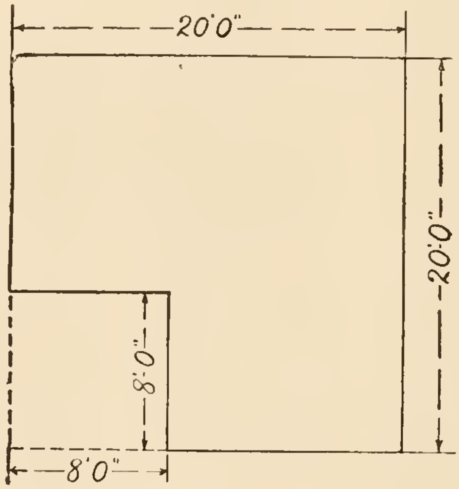
Answer—

$$15' \times 15' = 225'.$$
$$225' \times \cdot 7854' = 176 \cdot 7 \text{ square feet, area.}$$
$$176 \cdot 7' \times 12' \text{ (two-thirds of height)} = \underline{2120 \cdot 4 \text{ cubic feet.}}$$

Example 5.—An elliptical-shaped concert room measures on its longest diameter 25 feet, and on its shortest diameter 15 feet. It is 12 feet high, what is its cubic capacity?

Answer—

$$25' \times 15' = 375'.$$
$$375' \times \cdot 7854' = 294 \cdot 5 \text{ square feet, area.}$$
$$294 \cdot 5' \times 12' = \underline{3534 \text{ cubic feet.}}$$



PLAN.

Fig. 34

Example 6.—It is necessary to find the cubical contents of a space between the ceiling of a hall and the roof of the building. The roof is in the shape of a segment of a circle, and the chord is 24 feet long. The height of the segment is 3 feet, and the length of the roof 40 feet. What number of cubic feet are there in this space?

Answer—

Formula, $$\frac{H^3}{2 \text{ Ch.}} + (\tfrac{2}{3} \text{ of Ch.} \times \text{H}) = \text{area of segment.}$$

$$\frac{27 = \text{(cube of height)}}{48 = \text{(twice chord)}} + (\tfrac{2}{3} \text{ of } 24' \times 3')$$

$$= \frac{27}{48} + \left(\tfrac{2}{3} \text{ of } \frac{\overset{24}{\cancel{72}}}{1}\right)$$

$$=\frac{27}{48}+\frac{48}{1}$$

$$=\frac{27+2304}{48}=\frac{2331}{48} \text{ or } 48 \text{ square feet, area.}$$

$$48' \times 40' = \underline{1920 \text{ cubic feet.}}$$

In measuring the interiors of buildings, one comes across what at first sight appear to be difficult rooms to calculate their cubical contents correctly. To familiarise the student with these problems, we will now take a few examples showing how these little difficulties may be overcome.

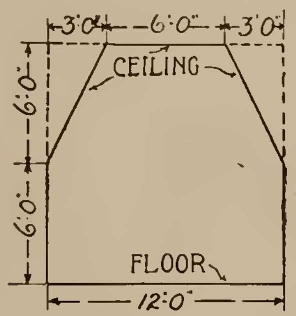


Fig. 35

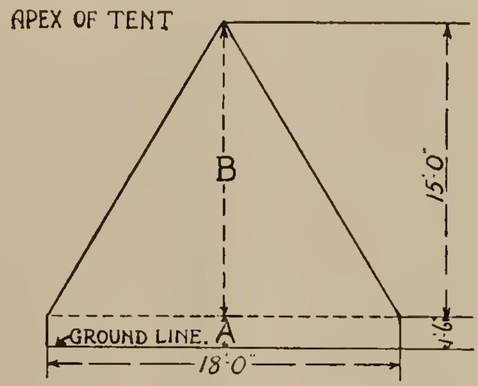


Fig. 36

In Fig. 34, we have the ground sketch plan of a room required to be measured. The room itself is 10 feet 6 inches high; we now have two alternatives of arriving at the proper cubical contents of the room, i.e. by dividing the sketch plan into two parts, working each part separately, and finally adding the results together, or by ignoring what we might term the missing corner until we finish the calculation of the area of the room as if the corner was included, then, having done so, work out the area of the smaller square, subtract from the first area obtained, and multiply the result by the height, when we have the cubic capacity of the room, as follows:—

$20' \times 20' = 400$ square feet, area of large square.
$8' \times 8' = 64$ square feet, area of small square.
$400' - 64' = 336$ square feet, area of room.
$336' \times 10{\cdot}5' = \underline{3528 \text{ cubic feet capacity.}}$

An attic room measuring 16 feet long is what is known as "camp-ceiled," i.e. the upper part of the walls incline inwards to the ceiling, as in Fig. 35. In this case, our working would be as follows:—

$12' \times 12' = 144$ square feet, being one end (gross).

From this we deduct the area of the two triangles which are equal to one rectangle measuring 6 feet by 3 feet :—

Thus, $6' \times 3' = 18$ square feet, and
$144' - 18' = 126$ square feet, nett area of end.
Hence, $126' \times 16' =$ 2016 cubic feet.

A type of question one sometimes meets with in examination papers is that of the bell tent. In this case, the " catch " is in its perpendicular sides as seen in Fig. 36. The tent is 18 feet in diameter, and 16 feet 6 inches from ground to apex, the sides being 1 foot 6 inches high. What are its cubical contents ?

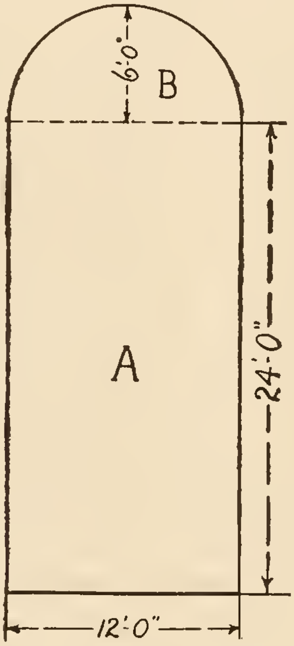


Fig. 37

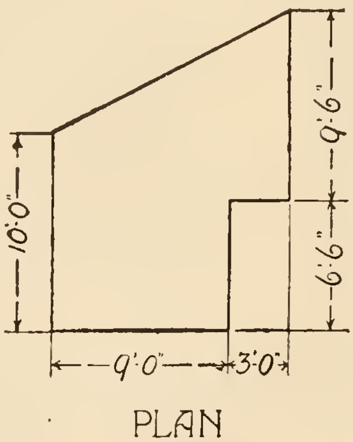


Fig. 38

" First divide the sketch into two parts, A and B, and then work out as follows " :—

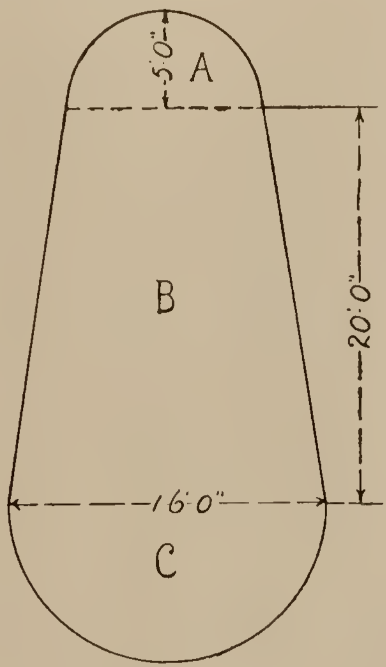
$A = 18' \times 18' = 324'$.
$324' \times \cdot 7854 = 254 \cdot 5$ square feet, area.
$254 \cdot 5 \times 1 \cdot 5 = 381 \cdot 5$ cubic feet in A.
$B = 254 \cdot 5' \times 5' = 1272 \cdot 5$ cubic feet in B.
$A + B = 381 \cdot 5' + 1272 \cdot 5' =$ 1654 cubic feet in tent.

Another example, combining a semicircle and rectangular floor space, is that shown in Fig. 37. The height of the building is 10 feet, the other measurements being as shown on plan.

Here again we divide our problem in two parts, and work each separately, viz. :—

$A=12' \times 24' \quad =288$ square feet, area in A.
$B=12' \times 12' \quad =144'$ (whole circle).
$144' \div 2' \quad =72'$ (half circle).
$72' \times \cdot 7854 = 56 \cdot 5$ square feet, area in B.
$A+B=288'+56 \cdot 5'=344 \cdot 5$ square feet total area.
$344 \cdot 5' \times 10' = \underline{3445}$ <u>cubic feet in room.</u>

In Fig. 38, we have an irregular-shaped room measuring 12 feet high. What are its cubic contents?



PLAN
Fig. 39

In this case we ignore the "missing" corner, and find first the mean length of the room; i.e.:—

$16'+10'=26$ feet.
$26' \div 2' \ =13$ (mean length of room).
$13' \times 12'=156$ square feet area;

but we must deduct a part of this space, viz.:—

$6 \cdot 5' \times 3'=19 \cdot 5$ square feet, area of corner.

Therefore, the proper area of the room is:—

$156'-19 \cdot 5'=136 \cdot 5$ square feet, true area of room.
$136 \cdot 5' \times 12'=\underline{1638}$ <u>cubic feet of room.</u>

Yet another type of irregular-shaped room is that given in Fig. 39, which shows the ground plan of a dormitory with a height of 10 feet from floor to ceiling.

To find the cubic capacity in this case, we divide the figure into three separate parts, A, B, and C, and then work out as follows:

$A = 10' \times 10' \quad = 100'$ (whole circle).
$100' \div 2 \quad = 50'$ (half circle).
$50' \times \cdot 7854 \quad = 39$ square feet, area in A.

$B = 16' + 10' \quad = 26'$.
$26' \div 2 \quad = 13$ feet mean width of room.
$13' \times 20' \quad = 260$ square feet, area in B.

$C = 16' \times 16' \quad = 256'$ (whole circle).
$256' \div 2 \quad = 128'$ (half circle).
$128' \times \cdot 7854 \quad = 100\cdot 5$ square feet, area in C.

$A + B + C = 39' + 260' + 100\cdot 5' = 399\cdot 5$ square feet total area.
$399\cdot 5' \times 10' \quad = 3995$ cubic feet in room.

Find the cubic capacity of a room, as shown in Fig. 40.

Here, we have a combination of a rectangular space and a segment of a circle. Dividing the sketch in two for the purpose of working out the problem, we letter these parts A and B, and proceed as follows:—

$A = 24' \times 10' = 240$ square feet;

$$B = \frac{216}{48} + (\tfrac{2}{3} \text{ of } 24' \times 6')$$

$$= \frac{216}{48} + \left(\tfrac{2}{\cancel{3}} \text{ of } \frac{\overset{48}{\cancel{144}}}{1}\right)$$

$$= \frac{216}{48} + \frac{144}{1} = \frac{216 + 2304}{48}$$

$$= \frac{2520}{48} = 52\cdot 5 \text{ square feet area.}$$

$A + B = 240' + 52\cdot 5' = 292\cdot 5$ square feet total area.
$292\cdot 5' \times 30' = 8775$ cubic capacity of room.

Should the area of any space "A" between two circles be required, as in Fig. 41, the method to employ would be to find the area of the two circles, and subtract the product of the inner one from the outer, viz.:—

$10' \times 10' = 100$ feet;
$100' \times \cdot 7854' = 78\cdot 5$ square feet, area of small circle.
$20' \times 20' = 400$ feet;
$400' \times \cdot 7854 = 314$ square feet, area of large circle.
$314' - 78\cdot 5' = 235\cdot 5$ square feet, area of space "A" between the two circles.

The application of these simple formulæ will solve any problem in connection with the calculation of cubic space when considering ventilation, and in concluding this chapter we will take one or two special examples which may be met with in actual practice.

Example 1.—A dormitory of a school for boys is 30 feet long, 9 feet 6 inches high, and 14 feet 6 inches broad. If 400 cubic feet of air space is allowed each boy, how many boys can sleep in the dormitory?

Answer:—

$30' \times 14{\cdot}5' = 435$ square feet, area of room.
$435' \times 9{\cdot}5' = 4132{\cdot}5$ cubic feet in room.
$4132{\cdot}5' \div 400' =$ 10 (fully) boys to sleep in room.

Example 2.—A room is 22 feet broad and 35 feet long, with its external walls along its length measuring 8 feet 6 inches and 11 feet

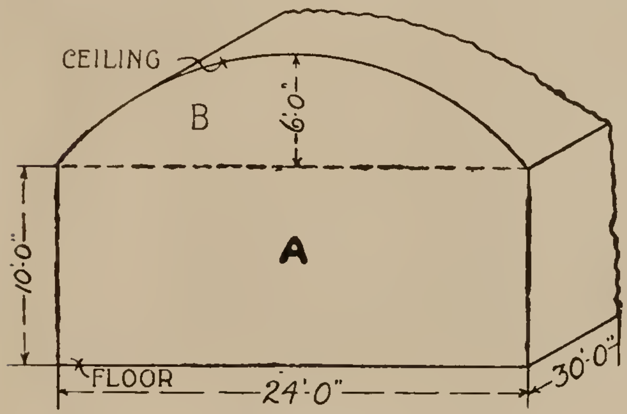


Fig. 40

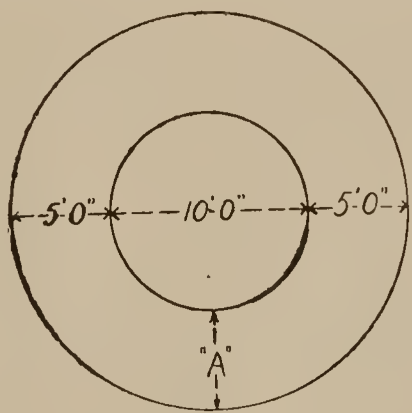


Fig. 41

6 inches in height respectively. How many persons would it accommodate, if used as a dormitory of a common lodging-house, where the model byelaws require 300 cubic feet for each person?

Answer:—

$35' \times 22' = 770$ square feet, area of room.
$8{\cdot}5' + 11{\cdot}5' = 20$ feet.
$20' \div 2 = 10$ feet, mean height of room.
$770' \times 10 = 7700$ cubic feet of room.
$7700' \div 300 = 25{\cdot}6$ or (fully) 25 persons who may sleep in the room.

Example 3.—A complaint as to overcrowding has been received by a Sanitary Inspector, who finds that there are eight members of one family occupying a single attic room of the shape shown in Fig. 42. Four of the inmates of the house are children under ten years of age. His authority has fixed the air space in dwellings for each person at 350 cubic feet per person. Was the room really

overcrowded ? (*N.B.*—Children under ten years of age are usually allowed half the air space of adults.)

Answer :—

$12' \times 10' = 120$ feet.

$\left.\begin{array}{r} 4' \times 4' = 16 \text{ feet} \\ 16' \div 2 = 8 \text{ feet} \end{array}\right\}$ area of triangular part.

$120' - 8' = 112$ square feet.

$112' \times 15' = \underline{1680 \text{ cubic feet of space in the room.}}$

Number of persons in room = 8.

Four of these are under ten years and equal 2 adults.

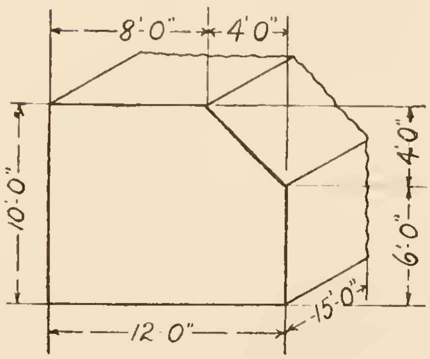


Fig. 42

Therefore, the total number of adults to be provided for is 6 :—

Hence, 350 cubic feet $\times 6 = 2100$ cubic feet space required, but there are only 1680 cubic feet in the room ; so that $2100 - 1680 = 420$ cubic feet are required in excess of the capacity of the room.

The room is therefore overcrowded to the extent of 420 cubic feet, or by fully one adult person.

Example 4.—Calculate the cubical contents of a room 30 feet long, 25 feet broad, and 10 feet 6 inches high, having a semicircular bay at one end 20 feet wide. How many persons can live in this room if the allowable air space is 350 cubic feet per head ?

Answer :—

$30' \times 25' = 750$ square feet, area of rectangle.

$20' \times 20' \times \cdot 7854 = 314$ square feet, area of bay.

$750' + 314' = 1064$ square feet, total area of room.

$1064' \times 10 \cdot 5' = 11{,}172$ cubic feet in room.

$11{,}172' \div 350' = \underline{32 \text{ persons (almost).}}$

Chapter VII

LAW RELATING TO AIR SPACE

We will now consider the legislation which has been introduced from time to time under various heads, and under which powers are given for dealing with ventilation, cubic space, etc., in factories, houses, and canal boats.

Public Health Act, 1875,

Section 91, *subsection* 5, "Any house or part of a house so overcrowded as to be dangerous or injurious to the health of the inmates, whether or not members of the same family";

Subsection 6, "Any factory, workshop, or workplace (not already under the operation of any general Act for the regulation of factories or bakehouses) not kept in a cleanly state, or not ventilated in such a manner as to render harmless as far as practicable any gases, vapours, dust or other impurities generated in the course of work carried on therein, that are a nuisance or injurious to health, or so overcrowded while work is carried on as to be dangerous or injurious to the health of those therein employed";

shall be deemed to be nuisances liable to be dealt with summarily in manner provided by this Act.

Section 93.—"Information of any such nuisance may be given to the local authority by the person aggrieved, or by any two inhabitants of the district, or by any officer of such local authority, or by the relieving officer, or by any constable or officer of the police force of such district."

Here we have definite ground to go upon in prosecuting any cases of overcrowding or want of ventilation. The local authority fix the standard of cubic space per person, and the officer of the local authority will then carry out the requirements.

Section 314.—"Any local authority may, if they think fit,

make byelaws for securing the decent lodging and accommodation of persons engaged in hop-picking within the district of such authority."

This section is extended in the Public Health (Fruit Pickers' Lodging) Act, 1882, section 2, which reads :—

"Section three hundred and fourteen of the Public Health Act, 1875, which enables any local authority to make byelaws for securing the decent lodging and accommodation of persons engaged in hop-picking within the district of such authority, shall be deemed to extend to and authorise the making of byelaws for securing the decent lodging and accommodation of persons engaged in the picking of fruit and vegetables."

In the **Canal Boats Act, 1877,**

Section 2, *subsection* 3, "The Local Government Board shall make regulations, and may from time to time revoke and vary such regulations :—

"For fixing the number, age, and sex of the persons who may be allowed to dwell in a canal boat, having regard to the cubic space, ventilation, provision for the separation of the sexes, general healthiness, and convenience of accommodation of the boat ; and

Subsection 4, "For promoting cleanliness in, and providing for the habitable conditions of canal boats."

The Local Government Board Regulations on Canal Boats require that in aft cabins 180 cubic feet of space, at least, ought to be provided for each person, while their Regulations as to fore cabins lay down a minimum of 80 cubic feet per person. Openings for the removal of foul air, besides doors and windows, must also be provided, while provision is also made to ensure adequate sleeping accommodation.

In *Section* 9 of the **Housing of the Working Classes Act, 1885,** it is enacted that :—

"A tent, van, shed, or similar structure used for a human habitation, which is in such a state as to be a nuisance or injurious to health, or which is so overcrowded as to be injurious to the health of the inmates, whether or not members of the same family, shall be deemed to be a nuisance within the meaning of section ninety-one of the Public Health Act, 1875, and the provisions of that Act shall apply accordingly."

In subsection 7 of this section it is worth while noting that—"Nothing in this section shall apply to any tent, van, shed, or structure erected or used by any portion of Her Majesty's military or naval forces."

In the **Dairies, Cowsheds, and Milkshops Order, 1885,**

powers are given the Local Government Board to frame regulations in regard to, among other matters :—

"For prescribing and regulating the lighting, cleansing, ventilation, and water supply of dairies and cowsheds in the occupation of persons following the trade of cowkeepers or dairymen."

In the **Regulations under the Dairies, Cowsheds, and Milkshops Order,** as laid down by the Local Government Board, provision is made for sufficient space for the animals kept in such cowshed as follows :—

For each cow kept in a separate stall there must be 8 feet by 4 feet of floor space.

Where two cows are kept together, the floor space for the two animals must be at least 8 feet by 7 feet ; 600 cubic feet must be provided for each animal where ventilation is perfect, and 800 cubic feet for each cow where ventilation is not perfect. All cubic space is to be measured by disregarding any height over 16 feet from the floor.

Factory and Workshop Act, 1901,

Section 3.—" (1) A factory shall for the purposes of this Act, and a workshop shall for the purposes of the law relating to public health, be deemed to be so overcrowded as to be dangerous or injurious to the health of the persons employed therein, if the number of cubic feet of space in any room therein bears to the number of persons employed at one time in the room a proportion less than two hundred and fifty or, during any period of overtime, four hundred cubic feet of space to every person.

" (2) Provided that the Secretary of State may, by Special Order, modify this proportion for any period during which artificial light other than electric light is used for illuminating purposes and may, by like order, as regards any particular manufacturing process or handicraft, substitute for the said figures of two hundred and fifty or four hundred respectively, any higher figures, and thereupon this section shall have effect as modified by the order.

" (3) There shall be affixed in every factory and workshop a notice specifying the number of persons who may be employed in each room of the factory or workshop by virtue of this section."

From the section quoted, it will be seen that we have a fixed standard to go upon, and while the amount of air space might be larger than that specified, we still have the power vested in the Secretary of State for increasing the cubic capacity per head, where evidence can be produced that such a step is desirable.

In *Section* 101, *subsection* 4 of the same Act, which deals with underground bakehouses, it is specifically stated that—" An underground bakehouse shall not be certified as suitable unless the

district council is satisfied that it is suitable as regards construction light, ventilation, and in all other respects."

In the application of the Act to *laundries*, we find the following in *Section* 103, *subsection* 3:—

" In the case of every laundry worked by steam, water, or other mechanical power :—

" (*a*) A fan or other means of a proper construction must be provided, maintained, and used for regulating the temperature in every ironing room, and for carrying away the steam in every washhouse in the laundry; and

" (*b*) All stoves for heating irons must be sufficiently separated from any ironing room, and gas irons emitting any noxious fumes must not be used ; and

" (*c*) The floors must be kept in good condition and drained in such manner as will allow the water to flow off freely.

" A laundry in which these provisions are contravened shall be deemed to be a factory not kept in conformity with this Act."

In the **Model Byelaws** of the **Local Government Board,** the requirements for a room in connection with **Houses Let in Lodgings,** and used exclusively for sleeping purposes, are three hundred cubic feet of air space for each person of an age exceeding ten years, and one hundred and fifty cubic feet of air space for each person not exceeding ten years. Where the room is not exclusively used for sleeping purposes, four hundred cubic feet of free air space must be provided for persons over ten years, and two hundred cubic feet of free air space for each person under ten years of age.

With **Common Lodging-Houses,** the local authority fixes the cubic space per person.

In the **Housing of the Working Classes Act, 1890,** powers are given to deal with obstructive buildings as follows :—

" If a medical officer of health finds that any building within his district, although not in itself unfit for human habitation, is so situate that by reason of its proximity to or contact with any other building it causes one of the following effects, that is to say :—

" (*a*) it stops ventilation, or otherwise makes or conduces to make such other buildings to be in a condition unfit for human habitation, or dangerous or injurious to health ; or

" (*b*) it prevents proper measures from being carried into effect for remedying any nuisance injurious to health, or other evils complained of in respect of such other buildings ;

in such case the medical officer of health shall represent to the local

authority the particulars relating to the first-mentioned building—(in this Act referred to as 'an obstructive building')—stating that in his opinion it is expedient that the obstructive building should be pulled down.

"Any four or more inhabitant householders of a district may make to the local authority of the district a representation as regards any building to the like effect as that of the medical officer under this section."

These are the principal sections dealing with this question of ventilation and cubic space, which are explanatory enough in themselves, and call for little comment. It will be seen that a good deal of "fixing the standard of air space for each individual" is left in the hands of the local authority of the district, and this must of necessity be so, as no two places are alike in local conditions, while the quality of the atmosphere itself varies according to whether the area is a congested one or otherwise. Now, these Acts apply throughout the British Isles, with the exception, of course, of the provisions of the Public Health Act, 1875, which only apply to England. In Scotland we have the provisions as laid down in section 16, subsections 7 and 8, Public Health (Scotland) Act, 1897, taking the place of section 91, subsections 5 and 6, of the Public Health Act, 1875, as applied to England, but these provisions and their powers are practically synonymous. The other Acts are operative throughout the country.

Chapter VIII

BUILDING SITES AND HOUSE CONSTRUCTION

While it is not the intention here to go deeply into the question of building construction, it is necessary—in the study of sanitary science—to acquire some little knowledge of sites and the proper construction of buildings erected on them, or at any rate points which, if omitted in the construction of such buildings, would lead to nuisances, also the services of the sanitary inspector or surveyor, and a considerable expense in remedying these defects or deficiencies.

Dealing first, then, with the selection of a **site** for building purposes, the important points to keep in mind in making the choice are—dryness, warmth, air, and light. We, unfortunately, frequently find that the situation of a house is far removed from those matters which make it suitable from a health point of view. Few of the general public seem to realise how important it is from a health point of view to have the proper locality, situation, and soil on which the house is to be built, no less than that of the outlook or aspect of the house itself.

Let us take the four points in their order as regards the selection of a site. First, then, we have **dryness,** which is mainly dependent on the facility with which rain or surface water can pass through or away from the soil, and the depth one has to go down to tap subsoil water. We have already seen in a previous chapter how the crust of the earth is made up of layers of pervious and impervious strata, and how the subsoil water gathers on the top of the upper impervious stratum. It follows, therefore, that where the ground is comparatively flat, and the soil between the surface of the earth and the top impervious stratum is shallow, we do not get a very desirable site unless it is well drained.

The ideal site for dryness is one which has a gravelly soil of a fair depth, and a slight slope. It is, however, very essential that the gravel be of a good depth, otherwise it will only act as a gathering ground or, at best, a natural drain for the subsoil water resting on the impervious stratum underneath.

Coming now to the second point of importance—namely,

warmth—it is a proved fact that this is influenced to a great extent by the nature of the soil, and whether such soil is of a wet or a dry nature. Different soils absorb heat in varying degrees, sand with some lime being the most susceptible to the sun's heat; but apart from the action of the sun's rays and the warmth of the site, one must remember that with the heat thus given off evaporation, to an extent proportionate to the dampness or otherwise of the soil takes place, and—as is well known—a loss of heat results because of evaporation; as greater evaporation takes place, the wetter will be the site. Hence, the greater the evaporation, the greater the loss of heat, thus resulting in a damp site, which is bound to be a cold one.

Where damp sites must be used, they ought to be thoroughly drained, and all means of natural drainage assisted as far as possible by removing any obstruction that may exist in the free flow of rivers, streams, etc., in the district.

By selecting a site with a southerly or south-westerly aspect, we will secure the maximum of **light,** which is a very important consideration. To secure the full advantage of **air or ventilation,** it is necessary to select a site well removed from other buildings, and not surrounded by trees. This, of course, is only possible in country districts, but recent legislation provides for more air in connection with buildings in towns and cities.

We will now consider the various natures of the soils one may meet with, and their suitability, or otherwise, for this purpose.

Of the various soils met with for building sites, the strongest—as far as foundations are concerned—are **impermeable rocks**. Such sites are invariably dry and healthy, but they increase the cost of any erections on them considerably owing to the difficulties they present in the way of opening trenches for drainage, and the introduction of water supply, etc. It must not be forgotten, however, that such a site is ideal from the point of view of uniform "settling" of the walls of any building erected thereon, providing no faults occur in the strata.

A **gravel** site is one of the best, especially if the gravel is of a good depth and compact. The greatest difficulty with a gravel site is where any excavations have to be made to any depth, when the sides of the trench or opening require to be "timbered" up; otherwise, this kind of site is one of the most desirable for building purposes.

Chalk soil is frequently met with, and is dry and healthy. Should the stratum immediately below the surface of the earth be removed, a very good foundation for walls of buildings is usually reached.

In a site containing **sandstone,** one finds much the same

conditions as with chalk. It need, therefore, only be pointed out here that it is desirable, in both these cases, that the chalk or sandstone be of considerable depth.

Among the commonest soils of sites, **clay** might be said to take first place, and closely associated with it is **marl.** Both of these are, in their original state, very undesirable for building sites as a rule. They are very damp—especially the former—and if a site selected should consist of one or other of these two soils, they then require to be thoroughly drained.

Where the site is of **sand,** it is very good, provided there is no risk of the sand being allowed to spread or be affected by water. This soil is dry, and as it is practically incompressible, it forms a good foundation for building purposes. The drawback here again is due to the fact that in any excavations which may be necessary, the sides of the work require to be timbered or " shored " up.

One other type of site requires to be mentioned here, and this is what is known as a **made soil** or ground. In other words, it implies a place which has been made, or filled up with rubbish and soil, where excavations have been carried out. Such sites ought to be shunned for building purposes. As will be seen by page 98, it is forbidden by Act of Parliament to erect houses on them.

This is easily understood when one remembers that these sites are usually the finished dumps in connection with towns. Places where all kinds of refuse and rubbish have been deposited in this way are fully charged with organic matter due to putrefaction of refuse. Thus, danger from this source will remain for years, and render the air immediately in contact with it impure.

Mention of this impure air brings us in touch with a very important matter in connection with soils, i.e. **ground air,** or the air which is intermixed with the ground from its surface down to the level of the subsoil water. This air is continually being changed owing to evaporation, or by rainfall, which forces the air out of the ground, and which is later replaced by surface air. From this, it will be seen that any soil which contains any animal matter, vegetable matter, or organic matter of any kind is very undesirable, especially as many authorities are now agreed that many diseases, such as diphtheria, infantile diarrhœa, etc., have a very close connection with ground air and ground odours.

Before passing on to the consideration of the treatment of soils, we will briefly sum up the position as regards sites.

The site of a house should be clean and dry ; sand or gravel form the best subsoil, clay is inferior ; but no matter of what nature the subsoil consists, it should always be covered with a layer of concrete. " Made up " sites are very undesirable, and in some cases it is illegal to build on them. Where there *is* no such re-

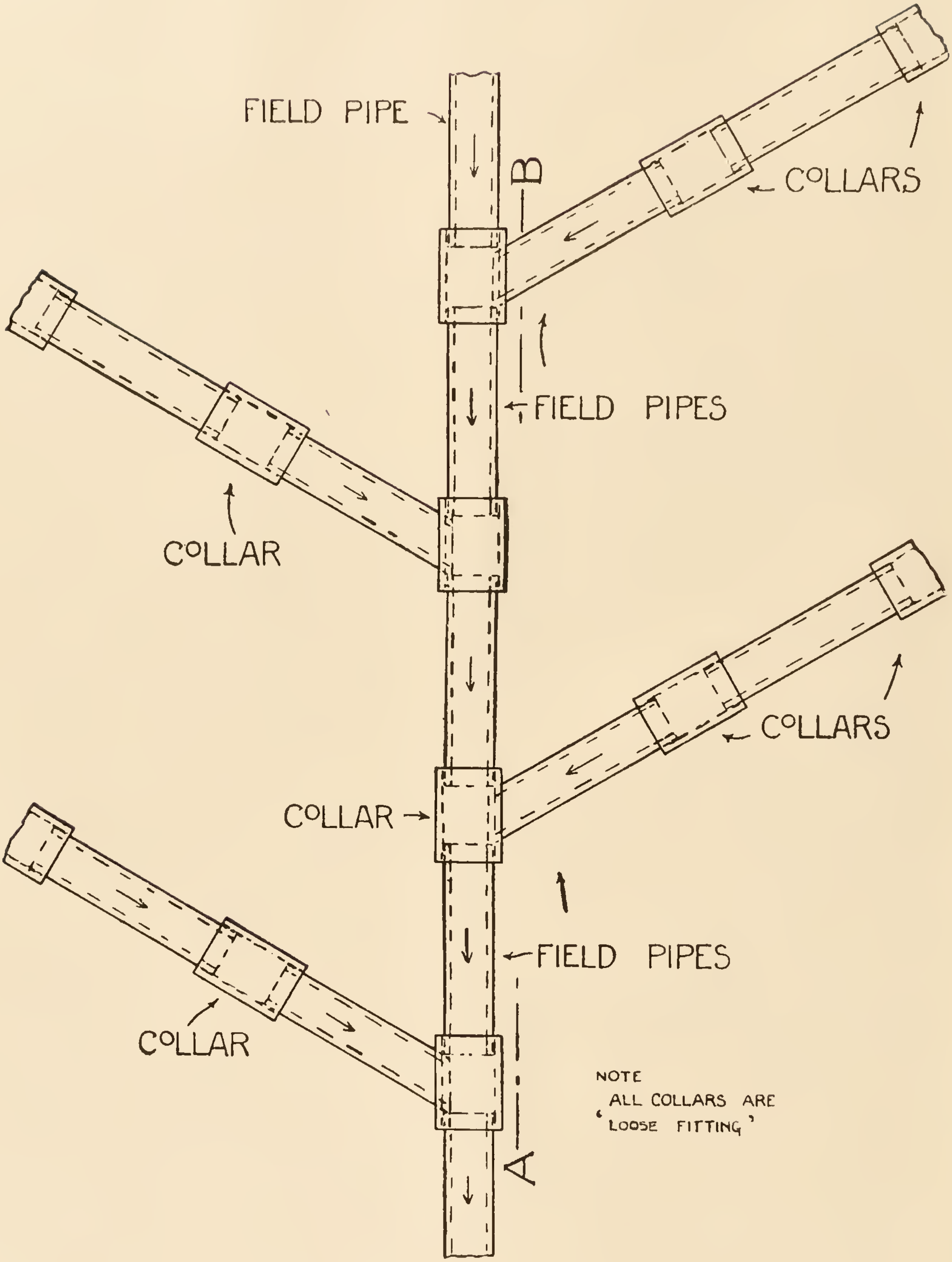
striction, they ought still not to be used for the purpose until all organic matter they contain has been rendered harmless. Even after such time, they ought to be covered with cement concrete for several reasons. Now, the principal reason is that of health; another is that when built upon without being covered with concrete, the walls may not "settle" uniformly owing to "pockets" which may have formed in the soil through decomposition of certain matter therein.

With regard to the *aspect of a house*, such affects the occupants greatly. It is an established fact that many of the microbes which are the cause of disease are killed by sunlight; hence, where possible, houses should be so arranged that the sun may shine into all the rooms during some portion of the day, and the rooms ought to be so arranged and planned as to obtain the greatest proportion of sunshine during the time they are occupied. If a house is planned with its external walls towards the cardinal points of the compass, the north side will never receive the direct rays of the sun, while on the other hand, if the house is set diagonally to these points, the sun will shine into every room during some part of the day. In towns where the houses are built in rows—if the streets are laid out north and south—the sun will shine into the windows on the east side in the morning, and on the west side in the afternoon.

In dealing with **wet soils** in sites, it is necessary that they should be properly drained by **subsoil drainage** or **under-drainage.** To do this, agricultural or field pipes are laid at a depth of about six feet or deeper, and run to some suitable outfall either into a stream or into the ground at a lower level. Such drains should not be connected to any drain or pipe conveying sewage, if it is at all possible to avoid doing so, but if no other way is available, then it ought to be joined to such sewer by an inspection chamber with a disconnecting trap at the junction of the under-drainage scheme and the sewer. It is also well to provide a flap valve on such trap as a protection against sewage entering the subsoil drain should a choke in the sewer occur. The system usually adopted in laying these under-drains is as shown in Figs. 43 and 44. The pipes, which are porous fireclay, are laid in the track with a few inches between them, and the joints are made with loose-fitting collars of the same material. Instead of the soil being replaced in the track around the pipes, the trench is filled in to a depth of from two to three feet with rubble or stone chips to induce percolation.

Having drained the site, it is very essential that that part on which the building is to stand should be covered with a layer of concrete to a depth of 6 inches.

Concrete for this purpose is best made to the following


FIELD PIPE
B
COLLARS
FIELD PIPES
COLLAR
COLLARS
COLLAR
FIELD PIPES
COLLAR
NOTE
'ALL COLLARS ARE
LOOSE FITTING'
A

PLAN

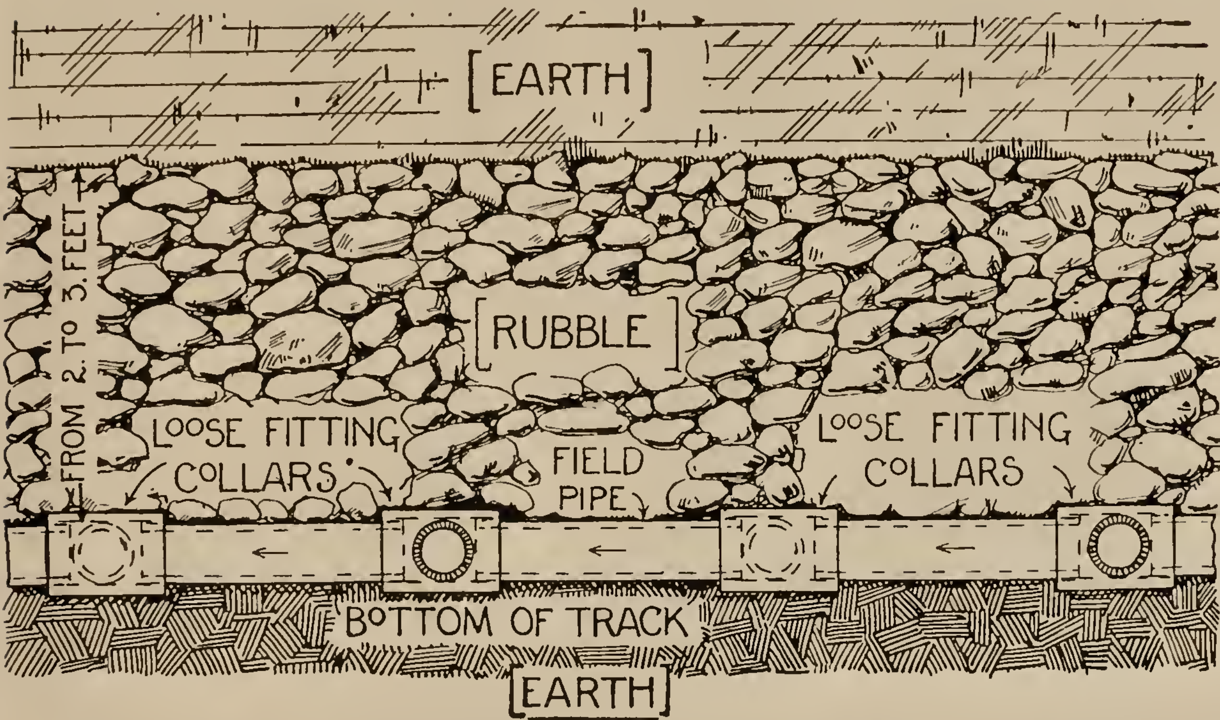
Fig. 43

specification, viz.: 1 of Portland cement, 1 of sand, and 5 of ballast.

As a further protection against damp and ground air, an additional layer is sometimes laid down over the concrete of asphalt three-quarters of an inch thick.

One of the common complaints which have to be dealt with in connection with houses is that of dampness. We will, therefore, proceed to a study of some of the causes of dampness, and the possible remedies for them.

We have already seen how a damp site, which has not been



SECTIONAL ELEVATION ON LINE A·B·

Fig. 44

under-drained or covered with concrete, may cause dampness. The water in the subsoil will rise by capillary attraction up the walls of the building, and it is interesting, here, to note that in our study of water and air we found that the former had an upward pressure of roughly ½ lb. to the square inch per foot of head, while the atmospheric pressure equals 15 lbs. to the square inch; thus if we take a wall 30 feet high we find that any water it may contain, due to capillary action, will press at that part 15 lbs. approximately, and the air pressure at the same point being 15 lbs., we have reached a position where the pressure being equal the water will not travel upwards any further.

Dampness in walls may be due to two causes: either by the

damp gaining access from the foundations, or, on the other hand, by gaining access at the top and travelling downwards. It is not very often, however, that we find many cases of the latter type, except in old or dilapidated properties.

To protect buildings against damp, it is necessary to provide a layer of impervious material in the structure of the wall called a **damp-proof course.**

This damp-proof course is inserted in all external walls above the ground level, and in internal walls under the lowest timbers.

The materials most commonly in use for damp-proof courses are: uncovered sheet lead, sheet lead covered on both sides with asphalt, Portland cement, glazed stoneware slabs, which may be had perforated longitudinally for ventilation purposes, slates embedded in cement, canvas impregnated with asphalt, and sometimes a layer of asphalt three-quarters of an inch thick.

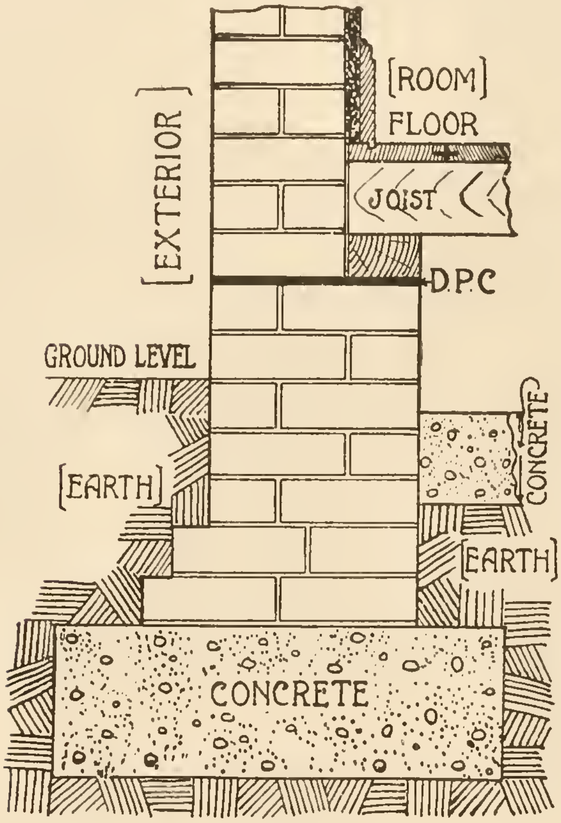
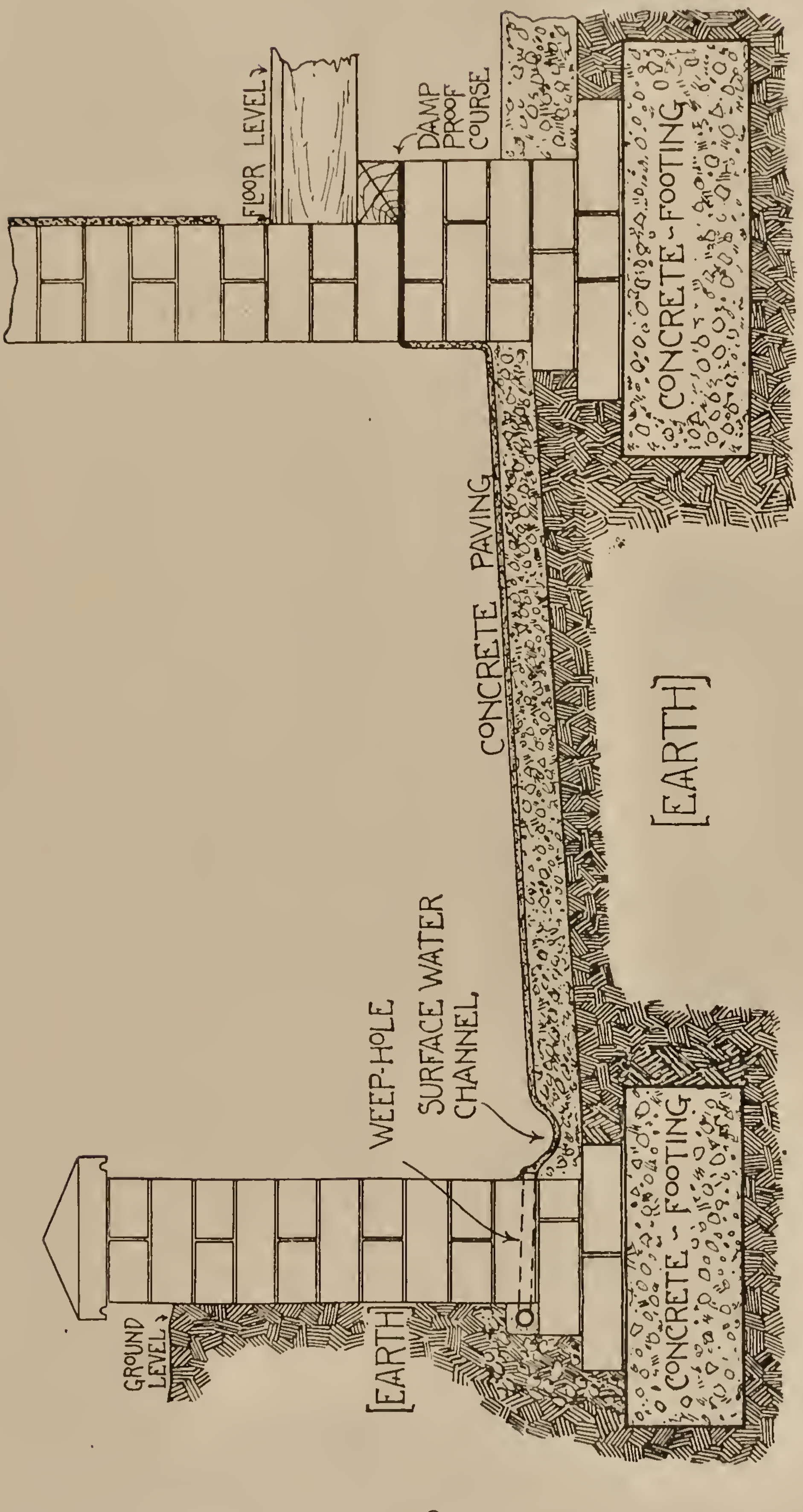


Fig. 45

Occasionally a damp-proof course is placed on the wall-head to protect the same against damp, but this is not very often necessary except where the walls are carried through and beyond the roofs.

Where the floor level is above the surface level of the site, the damp-proof course is introduced as shown in Fig. 45, but where the floor level is beneath the level of the surrounding ground, it is necessary to protect the external walls from contact with the earth, and this may be done in one of three ways. The first method is by forming a **dry area** round the whole of the house. This is done by excavating the earth to below the floor level of the house to a distance of three or four feet from the walls, and then building a retaining wall; or the ground may be sloped down to the bottom of the area. The area is paved with cement concrete, and where a retaining wall is provided, the concrete is given a fall towards the retaining wall and a channel is formed close to the latter to drain off all surface water from the area. Figs. 46 and 47 will explain this method with either a retaining wall or by the sloping of the ground.



TRANSVERSE - SECTION

Fig. 46

The second method is simply a modification of the first, and is what is known as the **air drain** method.

Where it is not practicable to build a dry area as just described, the air drain is made by building a retaining wall to a depth below the floor level of the house and about 12 inches away from the house wall. This retaining wall is carried up to the ground level, and a grating on top keeps out any rubbish. The bottom of the air drain is cemented, and given a fall to some point to carry off all surface water. Some builders, instead of leaving the area clear, fill it up with cement or asphalt, but when this is done, under-

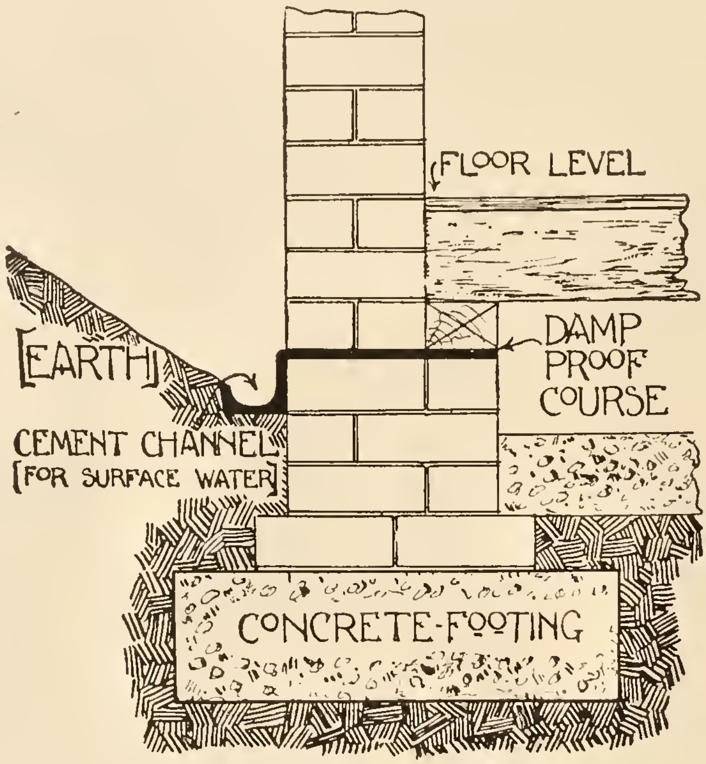


Fig. 47

floor ventilation, with which we shall deal later, is not so easily carried out.

The third method, as shown in Fig. 49, is what is known as the **hollow wall** method. This consists of a double wall with a double damp-proof course; the one being immediately above the foundations, and the other above the ground level. Such a method is highly satisfactory, and does not add so very much to the cost of the work.

Before leaving the subject of damp-proof courses, it will be well if we consider the various materials which have already been enumerated for the purpose.

Sheet lead—whilst costly—is excellent, and may be truly said to be the best type of damp-proof course which can be laid.

Glazed stoneware slabs are also very good, and—as previously pointed out—serve a double purpose by ventilating the space under the floor. The only trouble is that in some districts mice and other vermin make their way through the apertures, unless some means of protection, such as small mesh guards, are provided.

Where slates embedded in cement are used, the wall—in settling—may fracture them, and thus the purpose for which they

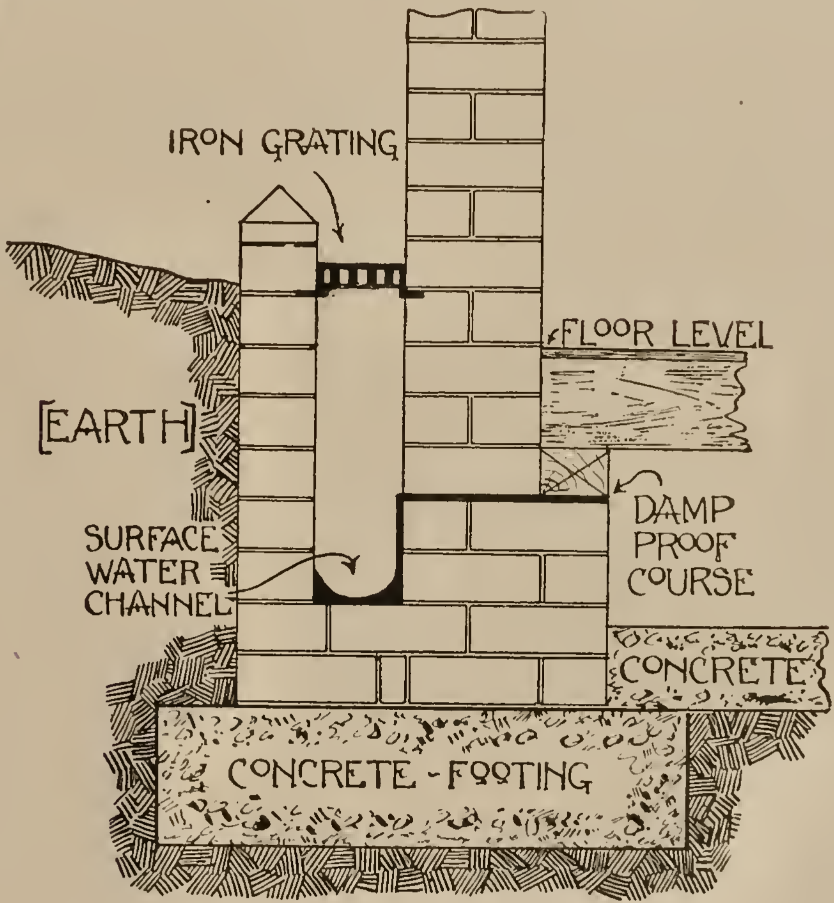


Fig. 48

are intended will be nullified. The same applies to asphalt and Portland cement, but in a less degree. Both are, however, quite good where the walls settle uniformly, but when from any cause the walls do not do so, then fractures are liable to occur through which dampness will gain access to the walls.

Pipes built into walls are a likely source of dampness from their being choked, broken, or through leaky joints. It is, therefore, far better that all pipes be erected in such a way as that they be kept clear of the walls by—at least—1½ to 2 inches.

Again, a common cause of dampness in walls is caused by defective or choked rhones, gutters, or spouts.

This, of course, is remedied by having these put into proper order or replaced by new ones.

Window sills are also often a cause of damp, especially if they are not built beyond the face of the wall and "throated," i.e. grooved longitudinally on the under-projecting surface.

Now, walls which are exposed to driving rains are liable to dampness unless they are coated externally with "waterproofed" cement or roughcasted, while sometimes slates or tiles are used.

Another method employed in the construction of houses—

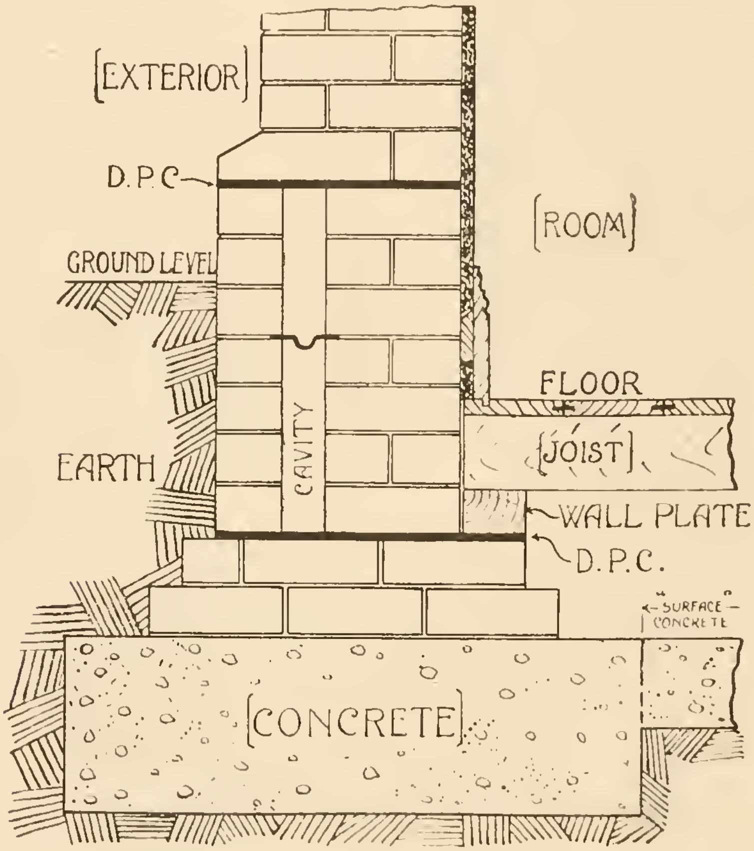


Fig. 49

and for which it is claimed that in addition to keeping away damp from the interior of the walls, it also keeps the temperature of the rooms more uniform—is by **hollow walls.** Buildings erected in this fashion have double external walls, with a space of from 2 to 3 inches between them. The walls are bonded together at suitable intervals by bricks or galvanised iron ties. In Fig. 50 a section of a hollow wall is shown. The space between the walls requires to be ventilated, and this may be done by ventilating bricks, gratings, or short pipes which have an upward direction imparted to the end inside the wall. The ties should be placed uniformly, and should be 3 feet apart horizontally and 18 inches vertically.

Gable and Parapet Walls, i.e. walls which extend beyond the roof, ought always to be finished in such a manner as to render the entrance of rain, etc., into the building impossible. These walls are usually finished on the top with stone slabs laid on a bed of cement and worked to some special outline designed to throw off the rainwater. The slabs are slightly broader than the wall itself, and when they are on the wall at a slope, they are termed gable coping-stones or gable copes. The cope of a parapet wall is frequently moulded and in the form of a battlement projected over the wall faces to keep same dry. The weak points, however, in the construction of both gable and parapet walls, are in what are known as the **flashings.** In cheap property of the common everyday class, the flashings are made of cement, which is really bad practice, as the cement sooner or later cracks or separates from the brickwork, and thus provides easy access for damp into the building. **Lead flashings** are *most* suitable for the purpose. Now these are stepped into the brickwork of the wall, as shown in Fig. 51,

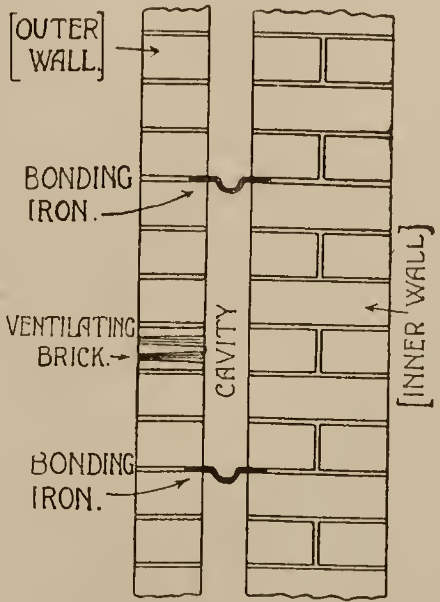


Fig. 50

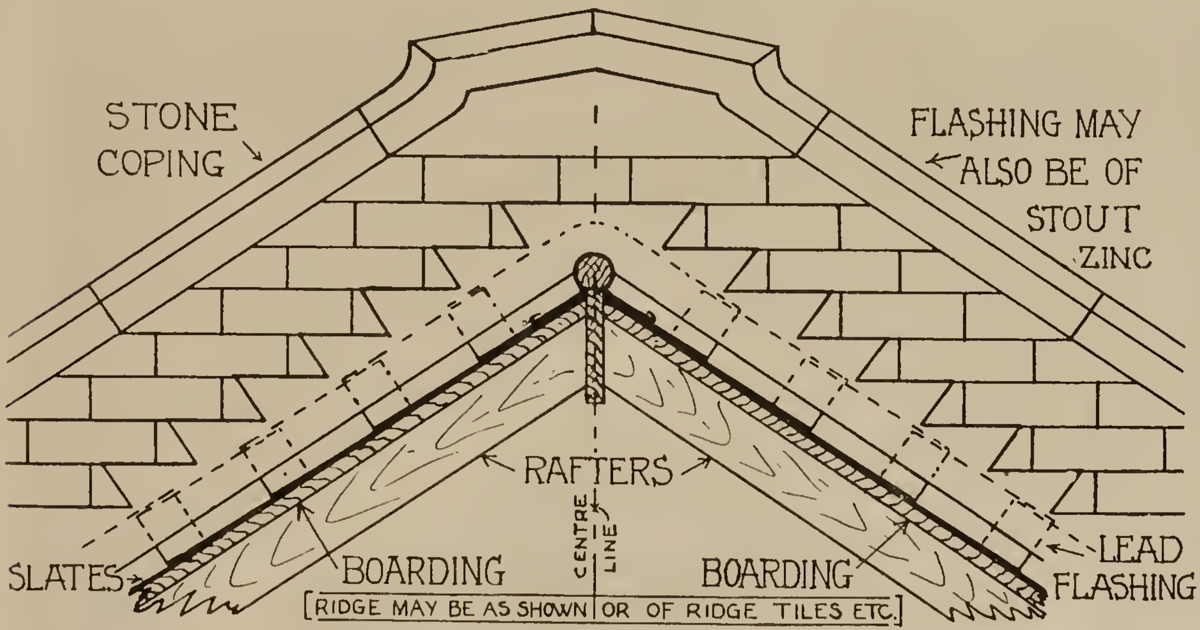


Fig. 51

and have adequate over- and under-lays. The latter are lead slates, termed "Soakers," and are generally laid next the vertical wall face and under the slating in order to further render

the building rainproof. The soakers are usually the size of the slates used on the special building, and are laid in a similar manner to the slating itself. It will be observed in Fig. 51 that the roof is a "pitch or span roof," and the stone coping shown is termed "gable coping." A parapet wall (with coping) serves as a means of protection to a flat roof or extensive "guttering," and this type of wall must not be confused with the fore-mentioned gable walls.

In dealing with the roofs of buildings, it is essential that they should be protected by impervious materials.

Slates or tiles are the commonest methods of covering roofs, although reinforced concrete and cement, etc., are also used.

Slates are often simply fixed on laths, but this method is not entirely satisfactory. The better course is to have the roof

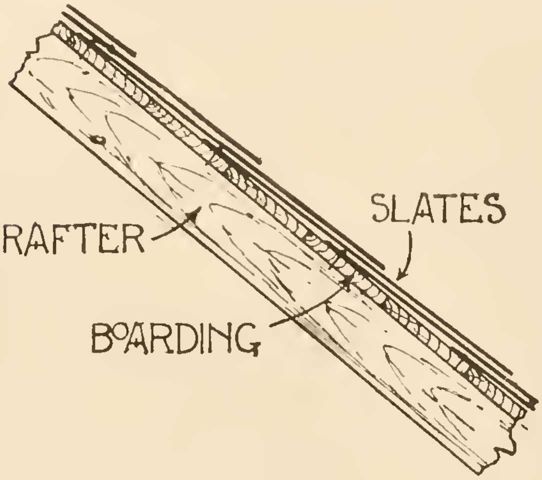


Fig. 52

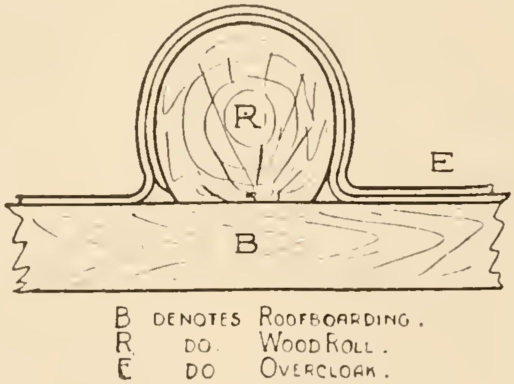


Fig. 53

first covered with boarding. In many cases not only is boarding employed, but a layer of inodorous felt is laid between the wood and the slates.

Slates should be fixed with copper, zinc, or composition (i.e. a mixture of copper and tin) nails. Iron nails are useless for the purpose, as they rust and break very quickly.

In fixing the slates, they should be so put on that the slates in the third row overlap those in the first row by (say) 3 inches, as illustrated in Fig. 52.

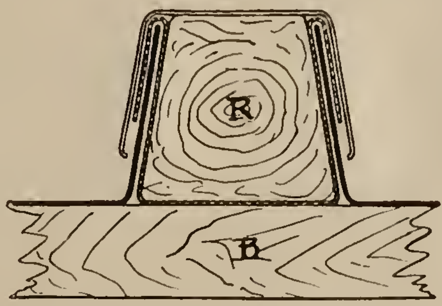
Tiles are usually fixed by pins, generally of oak, to laths, and pointed on the under side with mortar, which prevents the entrance of rain or snow, keeps the wind from blowing in, and stops the tiles from rattling in stormy weather.

With flat roofs, lead or zinc coverings are commonly used. In a **lead** roof, the thickness of the metal will depend a good deal on whether there is any possibility of the roof being walked upon or not.

As far as possible, nails should not be used in laying lead roofs on account of the galvanic action which takes place between the two metals. The method adopted is by making the joints over rolls, as shown in Fig. 53.

As the metal expands considerably with heat, it will be observed in this detail that the lead can travel over the roll, whilst its weight is quite sufficient to keep it in position on the roof.

Zinc is also often used for roof covering purposes, and is much lighter than lead. On the other hand, however, it is much more difficult to fix, and it will be observed in Fig. 54 that an angular roll is preferable for this purpose to a circular one by reason of the special nature of zinc.



B DENOTES ROOFBOARDING
R DO. WOOD ROLL.
Fig. 54

Coming now to the **interior of the house** where there are **basements,** the walls should be coated internally with cement or roughcasted, or they may be finished with tiles set in cement. The floors should be of cement concrete finished smooth and having a fall to a surface water trap. As an alternative to cement floors in basements, asphalt may be used, but this will not give the same satisfaction as cement.

Where there is no basement, it is important to remember that there should be free **under-floor ventilation.** This is attained by fixing gratings in the external walls under the floor level, and allowing the free passage of air under. By this means, "dry rot"—(which term is a misnomer)—is kept away, but there is a more important purpose to be served than that. Thus, in winter—during the time of hard weather—the soil becomes frost-bound and in this way ground air cannot make its escape, and consequently travels along seeking an exit which it finds in the spaces under the floors of houses which have not been covered with a bed of concrete. Now this ground air may be charged with leakages from gas mains, or sewer gas from leakages in drains and sewers, or organic matter from some mineral or vegetable deposit, and this entering a house has been proved to do a great deal of injury to the inmates.

The **flooring** of the rooms should be of thoroughly seasoned timber. Flooring boards are made in standard breadths and thicknesses and are finished with a groove or plough on the one side, and a tongue on the other, or in some cases the boards are simply grooved on both edges, the joints being made by means of strips of wood made to fit these grooves. Both types are shown in Figs. 55 and 56. In some cases metal strips are used instead of the

wooden beads for jointing the boards. It is very desirable that floors should be jointed in this manner, as it prevents dirt and dust from getting through between the same, forms a more solid floor, and in ground-floor rooms prevents the entrance of air.

Let us now consider briefly some of the building materials and their characteristics.

Bricks, as made in the Provinces, are usually 9 inches long, 4½ inches broad, and 3 inches thick. They should be heavy, hard, and well-burnt; and if one be taken in each hand and struck sharply against each other they ought to give out a clear ringing sound. Bricks absorb a good deal of water, and for this reason they should be thoroughly soaked before being used. Bricks, of course, are very porous, and for this reason they can assist in the ventilation of a house to a small extent, although it must not be forgotten that water can also enter where air can go.

As an alternative to bricks in buildings we have **stone,** and this of course varies as to suitability according to its variety. Stone,

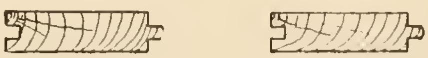


Fig. 55

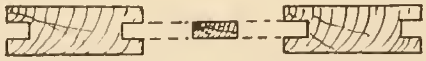


Fig. 56

of course, is greatly used even in brick buildings for window sills, etc., and it is no uncommon thing to find a builder putting in an inferior kind of stone.

The **mortar** used for either brick or stone buildings consists, as a rule, of three parts sand and one part slaked lime. The sand should be fairly fine, gritty, and clean. Unless it is clean, and should it contain clay or earthy matter from the adjoining ground, it will not set properly.

The interior of the walls are coated with **plaster,** and this should be applied in three coats, the first of which should consist of equal parts of lime and sand mixed with ox-hairs. In high-class work the plastering is not applied directly on the wall face, but this latter is first *strapped and lathed.* In this way dampness in walls is often avoided, and the space between the wall and the plaster makes for uniformity in the temperature of the air of the rooms.

Where it is desirable to have the plaster work of the walls set specially hard and smooth, and capable of taking on a high polish, *Keene's cement, Martin's cement,* and *Parian cement,* all mixtures of calcined gypsum and other substances, can be used in finishing the third layer of the plaster work.

The **concrete,** it need hardly be added, consists of cement, sand, and crushed stone or gravel, all mixed to the necessary strength required for the particular job in hand.

Wall papers used for decorative work should not be of the embossed type by reason of their dust-collecting propensities. A smooth paper is the most desirable, although in quite a number of houses sanitary wall paints are taking the place of wall paper.

All **cement** used in connection with building construction should weigh not less than 110 lbs. per imperial striked bushel. It should pass through a sieve having 2500 meshes to the square inch, leaving a residue of not more than 10 per cent. For *testing* purposes, the cement should be made into small pats or briquettes having a minimum section of $1\frac{1}{2}$ inches square and 1 inch thick, the cement to be gauged with pure water at 60 degrees Fahr.; every three consecutive pats to break at the end of 7 days, when an average tension of 800 lbs. and a minimum tension of 700 lbs. is applied, when the pats have been exposed to the air for the period mentioned; or they ought to withstand the same test if kept in water for 6 days. Another test is, when the cement is gauged it is poured into a thin glass test tube. The cement must not swell so as to crack the tube, nor shrink so as to become loose. A further test is to gauge a small quantity of cement in a pat a quarter of an inch thick on slate or plate glass. In this form it must bear boiling in water for half an hour without cracking.

One other matter which must not be omitted is *sound-proofing*, and which applies to partitions and flooring. A great variety of materials are used for this purpose, but one of the best, especially for floors, is *slag wool*, which—in addition to preventing sound passing from floor to floor—has the additional qualities of resisting fire and damp.

This material is placed in the space between the ceiling of the room underneath and the flooring, and, of course, between the joists. It consists of a mineral wool, and is a product of "slag," one of the waste products of iron smelting, and it is composed of pure silica which is blown into the consistency of wool by means of steam blasts when in a molten state. It is porous, and is a non-conductor of sound, whilst it is an equally good non-conductor of heat or cold.

As sanitary science does not necessarily embody a comprehensive knowldege of building construction, we have, therefore, merely dealt with the points which give rise to complaints from the occupiers of houses. With this knowledge acquired, we can deal with any question which may arise in the way of nuisances from damp houses.

Chapter IX

LAW RELATING TO BUILDING SITES AND HOUSES

UNDER the Public Health Act, 1875, Section 157, every Urban Authority may make byelaws with respect to the structure of walls, foundations, roofs, and chimneys of new buildings for securing stability, etc., and with respect to the sufficiency of the space about buildings to secure a free circulation of air, etc.

In the Model Byelaws on New Streets and Buildings, issued by the Local Government Board, the following are the provisions with regard to the subject we have had under consideration :—

First, **Interpretation of Terms.**—*Base,* applied to a wall, means the underside of the course immediately above the footings—if any—or, in the case of a wall wholly carried by a bressummer, the underside of the course immediately above the bressummer.

Party wall means :—(*a*) a wall forming part of a building and being used or constructed to be used in any part of the height or length of such wall for separation of adjoining buildings belonging to different owners, or occupied or constructed or adapted to be occupied by different persons ; or (*b*) a wall forming part of a building, and standing in any part of the length of such wall to a greater extent than the projection of the footings on one side, on grounds of different owners.

External wall means an outer wall of a building not being a party wall, even though adjoining to a wall of another building.

Public building means a building used, or constructed or adapted to be used, either ordinarily or occasionally, as a church, chapel, or other place of public worship, or as a hospital, workhouse, college, school—(not being merely a dwelling-house so used)—theatre, public hall, public concert-room, public ball-room, public lecture-room, or public exhibition-room, or as a public place of assembly for persons admitted thereto by tickets or otherwise, or used or constructed or adapted to be used, either ordinarily or occasionally, for any public purpose.

Building of the warehouse class means a warehouse, factory, manufactory, brewery, or distillery.

Domestic building means a dwelling-house or an office building, or other outbuilding appurtenant to a dwelling-house, whether attached thereto or not, or a shop, or any other building not being a public building, or of the warehouse class.

Dwelling-house means a building used or constructed or adapted to be used wholly or principally for human habitation.

Bressummer means a wooden beam or metal girder which carries a wall.

Second, **Exempted Buildings.**—Buildings which belong to His Majesty's Government or intended for His Majesty's use:—

County or burgh lunatic asylums, or buildings used for the detention of prisoners.

Any gaol, house of correction, bridewell, or prison, and any buildings used in connection therewith.

Any building belonging to any body of persons authorised by Act of Parliament to work any river, canal, dock, or harbour used exclusively for work under the said Authority, except any dwelling-house.

Any building, not being a dwelling-house, used in connection with a mine.

Any building erected to plans approved by the Land Commissioners for England, the Board of Agriculture, or the Board of Agriculture and Fisheries under the Improvement of Land Act, 1864, or other Act or Acts, for the improvement of the land.

Any building erected in pursuance of any statutory provision by one of His Majesty's Principal Secretaries of State, also any building used exclusively for plant-house, green-house, or conservatory.

Any building used exclusively as an orchard-house; summer-house, poultry-house, boat-house, coal-shed, garden-tool house, potting shed, cycle shed, or aviary which does not exceed six hundred cubic feet, or, if it does exceed such capacity and is used for keeping domestic animals, shall be wholly detached, and at a distance of at least ten feet from any other building.

Any building not exceeding thirty feet in height from footings, and not exceeding one hundred and twenty five thousand cubic feet, which is not a public building, and is not wholly or partially used for human habitation or as a place of habitual employment in any trade or business, and which shall be distant eight feet from nearest street, and at least thirty feet from nearest buildings.

Any building which exceeds thirty feet in height from the footings, and which exceeds one hundred and twenty-five thousand cubic feet, and which is distant at least thirty feet from nearest street and sixty feet from nearest building.

Any building erected as a temporary hospital, or used for the reception or treatment of persons suffering from infectious disease.

Before passing to the next part of the Byelaws, we must point out that in districts where Part III. of the Public Health Acts Amendment Act, 1890, has been adopted, Section 25 is in operation, which states as follows :—

"(1) It shall not be lawful to erect a new building on any ground which has been filled up with any matter impregnated with fæcal, animal, or vegetable matter, or upon which any such matter has been deposited, unless and until such matter shall have been removed by excavation or otherwise, or shall have been rendered or have become innocuous.

"(2) Every person who does or causes or wilfully permits to be done any act or contravention of this section, shall for every such offence be liable to a penalty not exceeding five pounds and a daily penalty not exceeding forty shillings."

We now come to that part of the Model Byelaws which deals with the structure of walls, foundations, roofs, and chimneys of new buildings for securing stability, and for purposes of health. Section 10 is only necessary where Section 25, Part III., of the Public Health Acts Amendment Act, 1890, has not been adopted.

10. A person who shall erect a new building shall not construct any foundation of such building upon any site which shall have been filled up with any material impregnated with fæcal matter, or impregnated with any animal or vegetable matter, or upon which any such matter may have been deposited, unless and until such matter shall have been properly removed by excavation or otherwise from such site.

11. Every person who shall erect a new domestic building shall cause the whole ground surface within the external walls of such building to be properly asphalted or covered with a layer of good cement concrete at least six inches thick, or four inches thick if properly grouted.

12. In every case where the intended site of a new building may have been or may have formed part of a clay pit, or where by reason of excavation and the removal of earth, gravel, stones, or other materials from such site, the whole or any part of the surface thereof may be at such a depth below the level of the surface of the ground immediately surrounding and adjoining such site as may render the elevation of the whole or part of the existing surface of such site necessary for the prevention of damp in any part of any building to be erected thereon :—

A person shall not construct any foundation of a new building upon such site or upon such part thereof as, for the purpose afore-

said, may require elevation, unless and until there shall have been properly deposited thereon a layer or layers of sound and suitable material sufficient to elevate such site or such part thereof to an adequate height and to form a stable and healthy substratum for such foundation.

N.B.—The next clause of this Act, which is applicable only to areas containing low-lying sites, deals with the specified height of any new buildings above a fixed Ordnance datum, and as only exceptional circumstances call for its adoption, we may omit it here.

14. Every person who shall erect a new building shall, except in such cases as are hereinafter specified, cause the external and party walls thereof to be constructed of good bricks, stone, or other hard and incombustible materials, properly bonded and suitably put together :—

(1) With good mortar compounded of good lime and clean sharp sand or other suitable material ; or

(2) With good cement ; or

(3) With good cement mixed with clean sharp sand. Provided always :—

(*a*) That such person may construct any external wall of such building as a hollow wall, if such wall be constructed in accordance with the following rules :—

(1) The inner and outer walls shall be separated by a cavity, which shall throughout be of a width not exceeding two and a half inches and shall be properly drained and ventilated.

(2) The inner and outer parts of the wall shall be securely tied together with suitable bonding ties of adequate strength formed of galvanised iron, of iron tarred and sanded, or of glazed stoneware. Such ties shall be placed at distances apart not exceeding three feet horizontally and eighteen inches vertically.

(3) The thickness of each part of the wall shall throughout be not less than four and a half inches.

(4) The aggregate thickness of the two parts, excluding the width of the cavity, shall throughout be not less than the minimum thickness prescribed by the byelaw in that behalf for an external wall of the same height and length and belonging to the same class of building as that to which the hollow wall belongs.

(5) All woodwork which may be intended to form the head of a door-frame or window-frame, a lintel or other similar structure, and may be inserted in the wall so as to project into or extend across the intervening cavity,

shall be covered throughout on the upper side thereof with a layer of sheet lead or other suitable material impervious to moisture in such a manner as effectually to protect such woodwork from any moisture that may enter the cavity.

(*b*) That where a new building intended for use as a dwelling-house shall be distant not less than fifteen feet from any adjoining building not being in the same curtilage, the person erecting such new building may construct its external walls of timber framing, subject to compliance with the following conditions, that is to say :—

(1) The timber framing shall be properly put together and the spaces between the timbers shall be filled in completely with brickwork or other solid and incombustible material.
(2) A thickness of at least four and a half inches of brickwork or other solid and incombustible material shall be placed at the back of every portion of timber.

(*c*) That where a new building forms or is intended to form part of a block of new buildings which shall be intended for use as dwelling-houses, and shall not exceed three in number, and each of which shall be distant not less than fifteen feet from any adjoining building, not being in the same curtilage and not forming part of the same block, the person erecting such new building may construct its external walls of timber framing, subject to compliance with the following conditions, that is to say :—

(1) The several buildings shall be separated by party walls each of which shall be constructed in accordance with the requirements of the byelaws in that behalf, and shall project at least one inch in front of any timber framing in any adjoining external wall.
(2) The timber framing shall be properly put together and the spaces between the timbers shall be filled in completely with brickwork or other solid and incombustible material.
(3) A thickness of at least four and a half inches of brickwork or other solid and incombustible material shall be placed at the back of every portion of timber.

(*d*) That where a new building, which comprises two or more storeys, forms or is intended to form part of a block of new buildings which shall be intended for use as dwelling-houses and shall not exceed three in number, and each of which shall be distant not less than fifteen feet from any other building, not being in the same

curtilage, and not forming part of the same block, the person erecting such new building may construct the external walls of the topmost storey—or if the building comprises more than two storeys, of the topmost two storeys—of timber framing covered with tiles, subject to compliance with the following conditions, that is to say:

(1) The timber framing shall be properly put together with sufficient braces, ties, plates, and sills.

(2) So much of any external wall as is below that portion which may be of timber framing covered with tiles shall be constructed of the same thickness and in other respects subject to the same conditions as would be applicable if the wall had been constructed throughout its whole height of good bricks, stone, or other incombustible materials.

(3) Every party wall in any such block of buildings shall be carried out at least to the external face of any timber framing in any adjoining external return wall.

15. Every person who shall erect a new building shall construct every cross wall, which in pursuance of the byelaw on that behalf may as a return wall be deemed a means of determining the length of any external wall or party wall of such building, of good bricks, stone, or other incombustible materials properly bonded and solidly put together :—

(1) With good mortar compounded of good lime and clean sharp sand or other suitable material; or

(2) With good cement; or

(3) With good cement mixed with clean sharp sand.

16. A person who shall erect a new building shall not construct any wall of such building so that any part of such wall—not being a part properly corbelled out or supported, or a projection intended solely for the purposes of architectural ornament—shall overhang any part beneath it.

17. Every person who shall erect a new building shall cause every wall of such building which may be built at an angle with another wall to be properly bonded therewith.

18. Every person who shall erect a new building shall construct every wall of such building so as to rest upon proper footings, or upon a sufficient bressummer.

He shall cause the projection at the widest part of the footings (if any) of every wall, on each side of such wall, to be at least equal to one half of the thickness of such wall at its base, unless an adjoining wall interferes, in which case the projection may be omitted where that wall adjoins.

He shall also cause the diminution of the footings to be in

regular offsets, or in one offset at the top of the footings, and he shall cause the height from the bottom of the footings to the base of the wall to be at least equal to two-thirds of the thickness of the wall at its base.

19. Every person who shall erect a new building shall cause the footings (if any) of every wall of such building to rest on the solid ground, or upon a sufficient thickness of good concrete or upon some solid and sufficient substructure as a foundation.

20. Every person who shall erect a new public building, or a new domestic building, shall cause every wall of such building to have a proper damp-proof course of sheet lead, asphalt, or slates laid in cement, or of other not less durable material impervious to moisture, beneath the level of the lowest floor and at a height of not less than six inches above the surface of the ground adjoining such wall.

Provided always that where any part of a floor of the lowest storey of such building, not being a cellar adapted and intended to be used for storage purposes only, shall be intended to be below the level of the surface of the ground immediately adjoining the exterior of such storey, and so that the ground will be in contact with the exterior of any wall, he shall cause such storey or such part thereof as will be so in contact to be constructed of walls impervious to moisture, or with hollow walls, constructed in accordance with the requirements of the byelaw in that behalf, and extending from the base of such walls to a height of six inches at least above the surface of the ground immediately adjoining the exterior of such storey.

He shall also cause a proper damp-proof course of sheet lead, asphalt, or slates laid in cement, or of other not less durable material impervious to moisture to be inserted in every such wall at the base of such wall and likewise at a height of six inches above the surface of the ground immediately adjoining.

Byelaw 22 deals with the thickness of party and external walls of varying heights and lengths, and has special provisions with respect to the distribution of walls by piers.

Byelaw 23 deals with the thickness of party and external walls in new public buildings and warehouses.

Byelaw 24 deals with the thickness of cross walls.

Byelaw 25 deals with buildings erected with materials other than bricks, suitable stone, or other incombustible substance.

Byelaw 26 deals with openings, left in walls, greater than one half of the vertical face of the wall. .

Byelaw 27 deals with the provision of parapet walls.

Byelaw 28(*a*) deals with carrying party walls to a certain height under certain circumstances.

Byelaw 28 (*b*) deals with roof flashings.

Byelaw 29 makes provision for coping party walls when carried beyond the roof.

Byelaw 30 stipulates that no opening shall be made or left in party walls.

Byelaw 31 deals with recesses in external or party walls.

Byelaw 32 deals with any chase made in a new wall.

Byelaw 33 prohibits bond timber or any wood plate.

Byelaw 34 deals with the position of ends of bressummer, beam or joists, and party walls.

Byelaw 35 provides for suitable templates for bressummers.

Byelaws 36 *to* 51 deal with the proper construction of chimneys.

Byelaws 52 *to* 58 provide for a sufficiency of space about buildings so as to secure a free circulation of air and with respect to the ventilation of buildings. *Byelaw* 55 deals with the provision of means of ventilation between the concrete or asphalt or other covering of the site and the underside of the flooring boards. *Byelaw* 56 makes the provision that rooms must be made with windows which open to the external air, the total area of such window or windows, clear of the sash frames to be equal at least to one-tenth of the floor area of such room. Such windows must be made to open to one-half their size. *Byelaw* 57 makes provision for ventilation by an air shaft, or sufficient aperture which shall provide an unobstructed sectional area of one hundred square inches at least, in rooms which are not provided with a chimney or flue connected with a properly constructed fireplace.

From the foregoing résumé of these Model Byelaws, it will readily be seen that ample provision is made, not only for the proper attention of sites for buildings but also with respect to the buildings themselves, and where a Local Authority has adopted these Byelaws, new buildings ought to give very little cause for complaint as far as structural requirements are concerned.

As already stated, if Part III. of the Public Health Acts Amendment Act, 1890, has been adopted by the Local Authority, then that too will assist in the proper regulations being enforced with regard to sites.

With regard to Scotland, Section 181 of the Public Health (Scotland) Act, 1897, subsection (1) reads :—

The Local Authority of any district other than a burgh may, subject to the approval of the County Council, make byelaws for the whole or any part of their district for regulating the building or rebuilding of houses or buildings, or the use for human habitation of any building not previously so used or any alteration in the mode of occupancy of any existing house, in such a manner as will

increase the number of separate houses in respect to the following matters :—

(*a*) The drainage of the subsoil of sites for—and the prevention of dampness in—houses intended for human habitation.

(*b*) The structure of walls, foundations, roofs, and chimneys of new buildings in so far as likely to affect human health.

(*c*) The ventilation of houses and buildings intended for human habitation.

(*d*) The sufficiency of the space about buildings to secure a free circulation of air.

Section 182 of this Act corresponds with Section 25 of the English Public Health Acts Amendment Act, 1890, from which it is taken. This reads as follows :—

(1) It shall not be lawful to erect a new building on any ground which has been filled up with any matter impregnated with fæcal, animal, or vegetable matter, or upon which any such matter has been deposited, unless and until such matter shall have been properly removed by excavation or otherwise, or shall have been rendered or become innocuous.

(2) Every person who does, or causes or wilfully permits to be done, any act in contravention of this section, shall for such offence be liable to a penalty not exceeding five pounds and a daily penalty not exceeding forty shillings.

Section 179 Burgh Police (Scotland) Act, 1892, also deals with the question of " made sites " in a similar manner.

Chapter X

DRAINS AND SEWERS

In this chapter we will engage in the study of a very important subject in sanitation, and one with which a sanitary inspector cannot be too fully acquainted. Drains fill a large part of an inspector's duty, and to deal with the various problems that arise in this connection calls for his thorough knowledge of the subject, and his ability to do so in an efficient manner concerns not only the health of the individual, but also in many cases the health of the community.

To the lay mind, the question of drainage appears to be a very complicated and mystifying one, but really such is not the case; and when one considers the great amount of danger and injury that can arise from faulty drains, it follows that work of this description should always be kept under strict supervision while it is in the course of progress.

Dealing first with the difference between drains and sewers, we can best take the definitions as laid down in the Public Health Act, 1875, Section 4, which are as follows :—

> " **Drain** means any drain of and used for the drainage of one building only, or premises within the same curtilage, and made merely for the purpose of communication therefrom with a cesspool or other like receptacle for drainage or with a sewer, into which the drainage of two or more buildings or premises occupied by different persons is conveyed."

> " **Sewer** includes sewers and drains of every description, except drains to which the word 'drain' interpreted as aforesaid applies, and except drains vested in, or under the control of any Authority having the management of roads, and not being a Local Authority under the Act."

These definitions differ slightly as regards drains in the Public Health (London) Act, 1891, where in Section 112 it states :—

" (*a*) A drain means and includes any drain of and used for the drainage of one building only, or premises within the same curtilage, and made merely for the purpose of communicating with

a cesspool or other like receptacle for drainage, or with a sewer into which the drainage of two or more buildings or premises occupied by different persons is conveyed, and also includes any drain for draining any group or block of houses by a combined operation under the order of any Vestry or District Board."

Broadly speaking, then, we might say that a drain conveys the waste liquids and solids from any single house or block of houses, while a sewer conveys the waste matters or sewage from the drains of a community.

Before we proceed to discuss the proper methods of drain and sewer construction, it will be as well to note here that in some districts, usually rural, we may come across two systems in vogue. These are, first, the water carriage system, where solid fæcal matter is allowed to enter; and, second, the conservancy system, where only waste waters are conveyed in the drains.

The first named is of course the type found in all large towns, or indeed where there is a collection of houses of any reasonable number and where proper water-closet accommodation has been provided.

In rural districts, with the dry-privy method of convenience, we usually have the second type of drainage.

In some exceptional cases double drainage is introduced, one set of pipes taking the excremental matter, the other the waste water, but, as will be readily understood, this system is rather costly to be universally adopted.

Let us take first, then, the question of drains, leaving sewers for later consideration. Drains must be so constructed that they comply with the principle of efficient and speedy removal of all sewage matter. They must necessarily be water-tight, have smooth inner surfaces, be uniformly laid with a regular sufficient fall, laid as far as possible in straight lines; if curves have to be introduced, they should be made with slow bends or, better still, by inspection chambers or manholes. Again, the drain should not be made of pipes with too large a diameter, and provision must be made for the ventilation of the drain so as to prevent air locking. Dealing with the question of the diameter of the pipes, it is no uncommon mistake to find pipes much too large in area being used, and as a consequence much of the flushing power of the liquid in the drain is lost, while if a pipe is never more than half full and there is not too much fall on the drain, it will be found that in time a coating of filth, or crust, will form just above the water-line of the drain, and, as this keeps on growing, it will in time lead to obstruction and possibly chokage of the drain.

It will generally be found that four-inch pipes are quite sufficient for any ordinary house drains, and where the house is

larger than the average, then six-inch pipes will more than meet all the demands made upon them.

The materials most commonly used for house drains are socketed glazed stoneware and iron.

Socketed Glazed Stoneware Pipes are made in standard sizes with corresponding bends, junctions, Y-pieces, etc. They must be laid in the trench with the socket end directed toward the way in which the sewage flows, and as a rule they are given a uniform minimum fall of 1 foot in 50 feet if such a fall can be obtained.

Pipes of this kind are supplied with a tested mark on them as to their soundness, but they ought always to be tested before being placed in position to ensure that they are in no way faulty; as, for instance, they may have become chipped or cracked in transit.

While examining them, it is also well to note if they are correct in outline, otherwise if they are not perfectly round the possibility is that the spigot will not fit properly in the socket. Make a point also of seeing that no internal part of the pipe has been missed in the glazing process.

With **Iron** pipes, one must see that they are of heavy enough metal to stand proper lead joints being made and that they will bear the weight of the soil which has to be filled in on top of them. These pipes are *also* made in standard lengths, covered with a coat of protective varnish, and have the necessary corresponding junctions, bends, handholes, lampholes, branch pieces, etc., made to fit in with them.

It may hardly appear creditable, but it is no uncommon thing to find, when an old drain is laid bare, the joints are very often made of clay, the pipes often of varying diameters and junctions made by the simple expedient of driving a hole through the pipe and puddling around the incoming pipe with clay. It is because of these things that one must labour the point of the standardisation of pipes and their accessories.

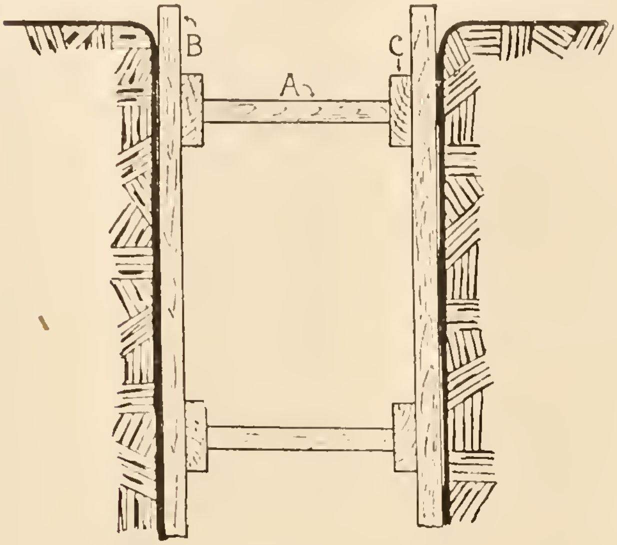
Having discussed the nature of the pipes to be used for this purpose, let us now look at the trench into which they are to be placed and note a few important points with regard to them.

If the ground in which the trench is to be made is of firm or solid soil, a great deal of trouble and inconvenience will be saved.

If, however, the ground is soft and friable, then some precautions must be taken against the sides of the trench caving in. This is done by what is known as "timbering" or "shoring up," a process in which stout battens of wood are placed edge to edge vertically along each side of the trench, another batten or battens

placed horizontally across them, and struts driven in to keep the whole in position as shown in Fig. 57.

If this precaution is not adopted, serious consequences may result by the falling in of the sides of the trench and possible injury to any one working in it. Having excavated the trench to the depth required, see that the bottom has the necessary uniform gradient and is not bumpy or uneven; also see that provision is made with regard to the places where the sockets of the pipes will rest. (See Fig. 58.)

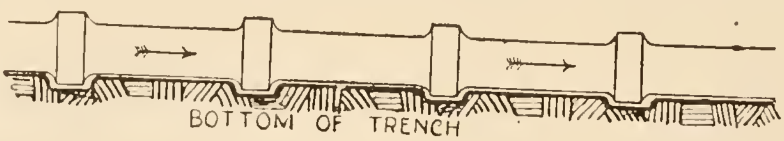


A. DENOTES - CROSS PIECES OR STRUTS.
B. DO - UPRIGHT BATTENS.
C. DO - LONGITUDINAL BATTENS.

Fig. 57

In explanation of this, a study of the sketch will show at a glance that if the pipes were laid on a bed without recesses being cut for the sockets, the chances are that in filling in the trench a cavity would be left immediately under the pipes, and the resultant weight of the soil above would tend to cause fracture of the drain, whereas by the simple expedient of removing a small part of the soil immediately beneath the joint, the whole body of the pipe is allowed to rest flat and so the weight is uniformly distributed. If the bottom of the trench is of wet soil or of ground that is not naturally firm, it ought to be filled in to a depth of six inches at least with good cement concrete, especially where stoneware drains are to be laid.

If for any reason it is unavoidable to take a drain under any



[ARROWS DENOTE THE DIRECTION OF FLOW OF SEWAGE]

Fig. 58

house, then iron drains should be used, but if fireclay pipes are to be utilised the whole drain running under the house must be embedded in cement concrete to a depth of at least six inches in all directions.

One other point worth noting with regard to the preparation

of the trench is that if by any reason too much soil has been excavated and has to be replaced, then it must be firmly beaten down and not simply thrown loosely into the track.

Having prepared the trench, the pipes should now be laid with the socket end directed toward the flow of sewage as already noted.

If a stoneware drain, the joints should be made as in Fig. 59, that is, by first placing a few strands of spun yarn in the annular space between the spigot and socket; this should be well rammed home and the joint then made with the best Portland cement. Extreme care must be used in making these joints not only as regards the proper finish on the outside of the pipe, but it should always be seen that no cement has found its way inside the pipe at the joint.

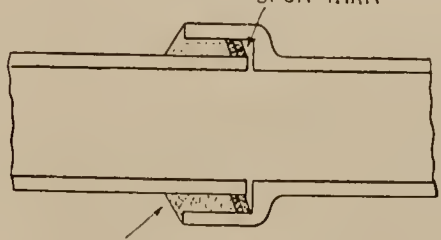


Fig. 59

The workman can easily do this before proceeding to make the next joint by raking out the pipe with a circular-shaped piece of wood fitted to a handle.

Should this not be done, and any cement left inside the pipe, it will set and harden and cause obstruction and chokage of the drain.

Before leaving this class of cement joint, it may be as well to mention that if the best Portland cement is used of known quality and properly tested, it can be safely used without the addition of sand; but many prefer to use equal parts of clean sharp sand and best Portland cement as a precaution against expansion on setting.

A simple method to find the fall required for house drains is to multiply the diameter of the pipe by 10 and to the length found in inches give one inch fall, thus:—

$4 \times 10 = 40 = 1$ inch of fall in 40 inches of drain.
$6 \times 10 = 60 = 1$,, ,, ,, 60 ,, ,, ,,

In circular drains, such a fall is stated to give a velocity of about 5 feet per second running two-thirds full and about 3 feet per second running one-quarter full.

In connection with glazed stoneware drain joints, many patents have been brought out, but as these are not universally used, it will suffice here if we only take one or two of these, with a brief description of them.

Messrs. Doulton and Co. Ltd., of Lambeth, make what was one of the first of these patent joints in what is known as the **Stanford Joint,** shown in Fig. 60. On the spigot end of the pipe a composition is applied made convex in shape, while a rim of

similar material is cast around the inner side of the socket. In this case, however, the preparation is smooth and flat and not convex, while a small space is left to finish with cement if desired. The method of making the joint is quite simple. The socket and spigot are first wiped clean and a little lubricant applied to the composition ; the spigot is then entered into the socket and pressed home. The advantage claimed for this joint is that, acting on the ball-and-socket principle, should subsidence take place after the drain has been "filled in," this joint will automatically adjust itself without in any way impairing the efficiency of the joint, whereas with an ordinary cement joint, either the pipe or the joint would have to give—in some way—under like circumstances.

Another type of patent joint is that shown in Fig. 61 and known as **Hassall's Patent.** This kind of joint is frequently used where difficulty is experienced in making the ordinary joint.

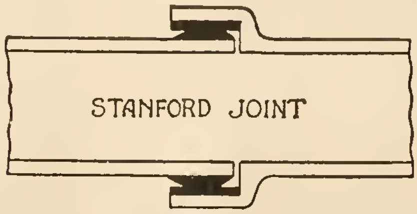


Fig. 60

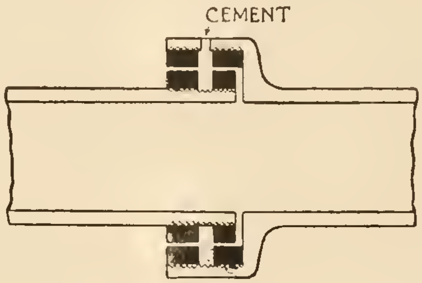


Fig. 61

In this case a double band of bituminous material with a space between the bands is cast on the outside of the spigot and inside of the socket. Two small holes are left over the annular space in the socket end ; these holes must, of course, be on top of the pipe when in position. The ends of the pipes are first cleaned, and then lubricated and pressed home, and fluid cement or cement grout is poured in through one of the holes on the top of the socket until it overflows at the other hole.

One more patent joint calls for our attention, namely, the **Archer Patent.** This joint is made with liquid cement. The spigots and sockets are specially prepared, and a hole is left on top of the socket. After the pipes have been placed in position, a film of clay is put inside the annular space between the two pipes in order to ensure that none of the cement makes its way inside. The liquid cement is now poured in at the hole on top of the socket, and so the joint is made.

Where **Iron Drains** are laid, the joints must be *caulked with lead.* The method of making the joint is as follows : the spigot having been inserted in the socket, a few strands of spun yarn are well rammed home in the space between the two pipes. Next

"a luting of clay" is placed around one of the pipes so that it closes the annular space and keeps the molten lead in place, a small part of the clay at the top of the joint being left open; through this opening the molten metal is poured, and after cooling it is thoroughly caulked by means of a caulking iron and hammer. The depth of the lead forming the joint should never be less than two inches, and more with pipes of larger diameter than four inches.

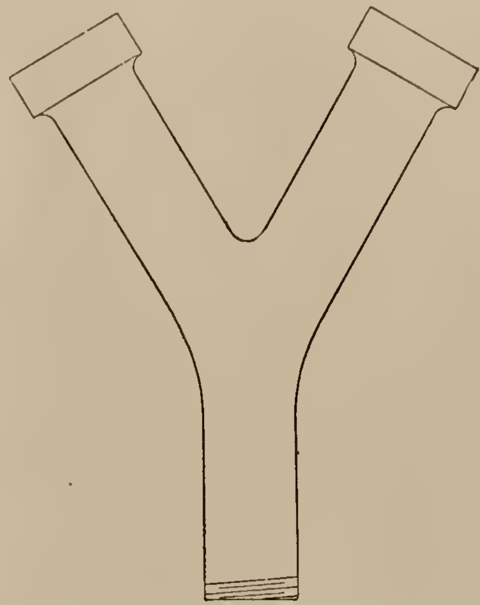


Fig. 62

So much, then, for the trench and the drain as regards running in straight lines; where junctions come into the main drain, these are made with what are known as Y-pipes, as shown in sketch 62. Here the sewage from the branch drain is carried into the main drain with an easy angle in the direction of the flow of the drainage. Pipes are also made with a branch, set at right angles to the pipe itself, as in Fig. 63, but these are only used as junctions under exceptional circumstances, and are mainly used when a connection from the top is desired, such as in the case of a drain on a higher level being carried into another drain on a lower level than the first, or where a W.C. is carried straight down and joined to a drain immediately underneath it. Where more than one branch drain enters the main drain, a double Y-pipe is used as in Fig. 64, but in this case the junctions to the main drain ought to be made with channel pipes, contained within a properly constructed inspection chamber. Where the drain has to be carried in another direction to the course it has been following, bends are employed, and of these there are three distinct types, as shown in Fig. 65. These are known as (1) knuckle bend, (2) right-angle bend, and (3) slow or easy bend.

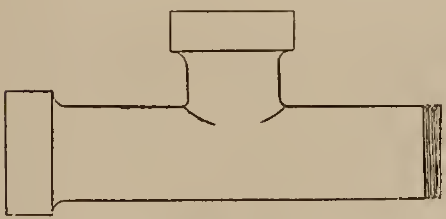


Fig. 63

Here again, as with junctions, it is always desirable to have bends constructed within an inspection chamber, and in all cases the bend should be as easy a one as circumstances will allow.

Where it happens that the diameter of pipes throughout the whole drainage system is not uniform, especially in the main drain, where perhaps it is found necessary at some point to increase the diameter of the drain from say 4 inches to 6 inches, then we

employ special conical-shaped pipes which have a diameter of 4 inches at one end and 6 inches at the other. This not only obviates a form of scamp work which was very often practised, of putting the end of the small-diameter pipe into the socket of the larger one and making a rude joint of clay, but it also gets over the difficulty that sometimes arises where it is found necessary to reduce say a 6-inch diameter drain to a 4-inch, and where the tradesman would make a rough and ready cement connection with bricks, or simply stick a 4-inch diameter pipe into a 6-inch one and then make a cement joint, the result being, of course, that a

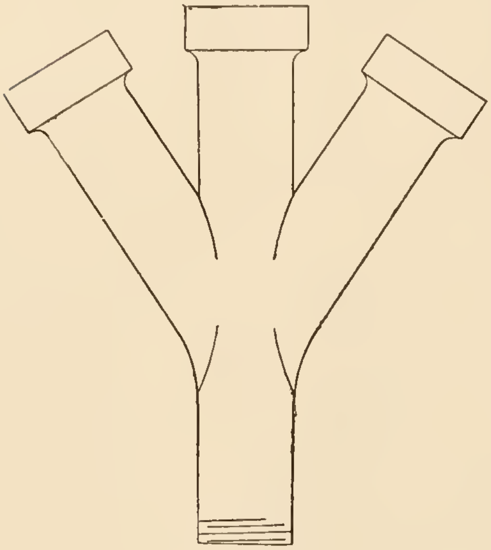


Fig 64.

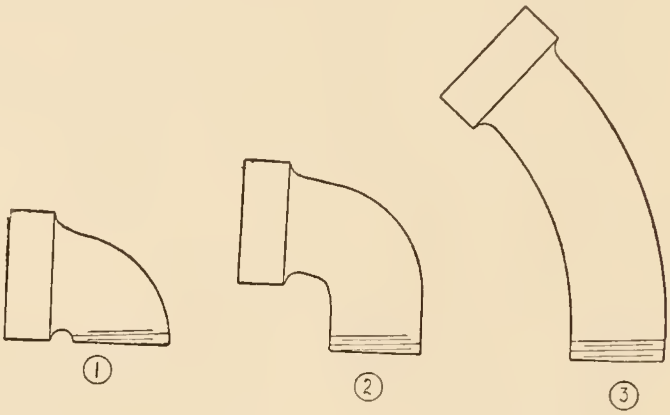


Fig. 65

barrier to the free flow of sewage would be created from the very first and get worse as time went one, causing continual chokage of the drain and ultimately the lifting of same.

Another point with regard to pipes, whether stoneware or iron, is that all types of pipes, straight, junctions, bends, etc., can be acquired made with covers, which allow of them being used for inspection purposes. They are also made with hand holes and lamp holes.

We have not dealt with the atrocious method of attempting to make bends with straight pipes, as such a thing is rarely met with in new drainage ; but in opening up old drains it is no uncommon thing to find that the tradesman who laid the drain has attempted to make a bend in this manner. A minute's reflection and a glance at Fig. 66 will show how impossible such an attempt is.

Again, we have referred to old drains having been made with clay joints. Apart from the unsuitability of clay for this purpose, it is often found that chokage in drains is caused by tree and shrub roots and fibre growing in through the joints right into the drain itself.

Having now dealt with the suitable pipes to be used for drains, the proper joints, bends, junctions, etc., let us consider how the various matters which enter the drain are conducted there, and the important question as to whether they enter the drain direct or are in some way disconnected from the drain itself.

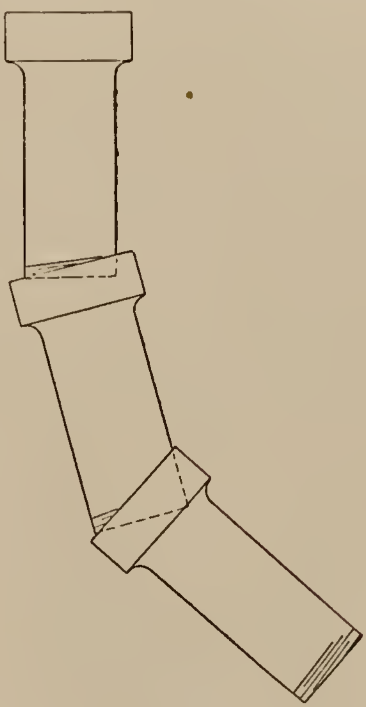


Fig. 66

Here let us say that every branch of a drain must be disconnected or trapped at some point in its course.

This is usually a difficult matter for the student to get hold of, and yet there is really no difficulty in it. We will therefore try to make it as simple as possible by putting it as follows :—

All waste from water-closets, slop sinks, and urinals is carried direct into the drain, being trapped either at the W.C. basin, the urinal basin, or the slop sink.

All waste water from sinks, wash tubs, baths, roof water, wash-hand basins, etc., is not only trapped under the convenience itself, but the waste pipe conducting such water down the outside of the building must discharge over a trap placed at the top end of the branch drain to receive the waste water from such pipe. (As shown in Fig. 67.)

We know, of course, that many authorities hold that such an intercepting trap is really not necessary, but it serves a very useful purpose indeed, and is a protection against the escape of sewer gas inside the building ; again, no work of any importance is done without them. These traps are made in different sizes and shapes, so that it is not difficult, whether the drain be of iron or stoneware, to get the proper kind of trap required for the work in hand.

While on the subject of traps for drains, it may not be out of place here to state that special traps are made for drains which are subject to tidal or other form of backflow. These traps, of course, are at the outlet of the drain.

Among these are **flap valve traps,** where a hinged flap is suspended in the trap itself, and on any back flow of water the flap is pushed back against the face of the interior of the drain, thereby preventing the water from getting back into the drain. Unfortunately for the success of this type of trap, any matches, pieces of paper, or solid sewage in suspension which gets between the flap and the end of the pipe keeps the flap from serving the purpose for which it is intended. Messrs. Doulton and Co. Ltd.,

of Lambeth, are the makers of this kind of trap, a modification of which is shown in Fig. 68. Then we have the **ball valve trap,** where a ball of copper floats in the water of the trap, but immediately there is any tendency to the flow of back water, the ball is raised and fills the opening in the drain—otherwise the inside of the pipe. Here again the drawback is that any matter which may be in the sewage or drainage may get between the ball and the pipe, the result being that the back flow of water is then not arrested.

One other type, and the one that gives entire satisfaction where precautions against flooding have to be adopted, is that known as the **screw-down trap.** With this trap, a shut-down valve is provided, and at the first sign of back flooding the trap is screwed down so that no water can get back up the drain.

We will now consider the proper construction of inspection

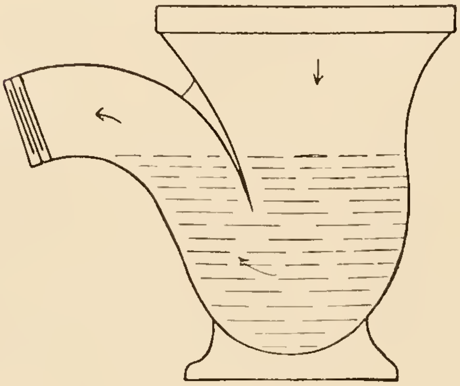


Fig. 67

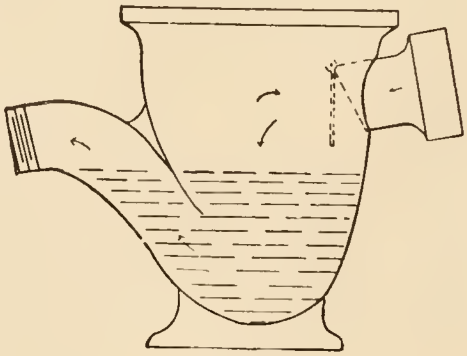


Fig. 68

chambers. As already stated, where bends are unavoidable, it is always desirable that inspection chambers be provided, and again, where more than one branch joins the main drain, it is an advantage that the junctions be made in an inspection chamber. The chamber itself is simple in construction, being built of good bricks set in cement. It is very important that this should be the case, as should there be a choke in the drain at any time, and the brickwork not soundly jointed, then the sewage water will seek its way into the surrounding soil ; and while the chokage may be cleared in a very short time, still the liquid filth which has mixed with the soil and come in contact with the ground air may do a great deal of harm. The floor of the chamber ought to be laid with good cement concrete, and should slope from all the sides of the chamber towards the centre where the half-pipe channel, etc., is. This floor at its lowest point ought to be level with the top edge of cover of the inspection pipe.

If the drain is an iron one, this cover of the inspection pipe will be held in position by two clamp irons and screws, the edges

of the cover being made to fit a checked recess cut in the top of the pipe.

If a stoneware drain, then the inspection cover is bedded down with clay—not cement, as, if that is done, then the whole cover will have to be smashed to get it off if wanted at any time. Inspection chambers are usually finished at top with a stone flag, into which a close iron cover is fitted.

Now we come to the question of ventilation of drains. All drains must of course be ventilated, and the point selected for the outlet is the highest point of the drain. Very often a soil pipe stack, carried clear of all openings to the building, can be used for the purpose, but where this cannot be done, then a shaft of the same diameter as the drain itself must be carried up from the highest point of the drain to a height sufficient to allow the sewer

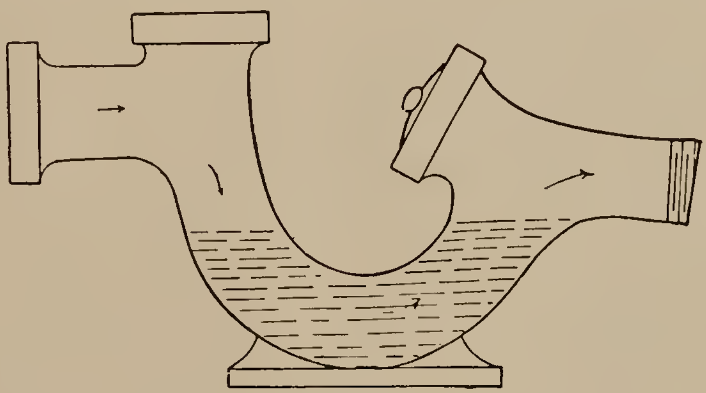


Fig. 69

gas to be diffused in the air without giving cause for complaint or causing injury, particular care being taken to see that such ventilation does not take place near to any openings in a building. The next important matter is the disconnection of drains before entering a sewer or cesspool. In many cases this disconnection by traps is being omitted, and it is just as well to point out that by doing so the owner of a private drain may find himself suffering from the carelessness or shortcomings of his neighbours. It is always well to go to the little extra trouble of putting in a good disconnecting trap at the point where the drain joins the sewer; indeed many Local Authorities have made it compulsory in their byelaws that such be done. This trap is ventilated in the manner shown in Fig. 69.

In dealing with this subject of drainage, then, we find, when we come to sum up the whole matter, that :—

1. Great care ought to be taken in excavating the trench.
2. If soil is loose, "timbering up" ought to be resorted to.
3. Good tested pipes only ought to be used.

4. Pipes ought not to be of too large diameter.
5. Proper joints require to be made.
6. Branch drains ought to join at inspection chambers.
7. Bends ought to be as easy as possible, and be in inspection chamber.
8. All soil pipes are to be carried direct to drain.
9. All waste water pipes are to be disconnected at the ground level by traps.
10. A proper disconnecting trap should be interposed in the drain where it joins a sewer or cesspool.
11. All drains must be ventilated at their highest point by means of a shaft of the same diameter as the drain itself, and carried to a height clear of all openings to any building.

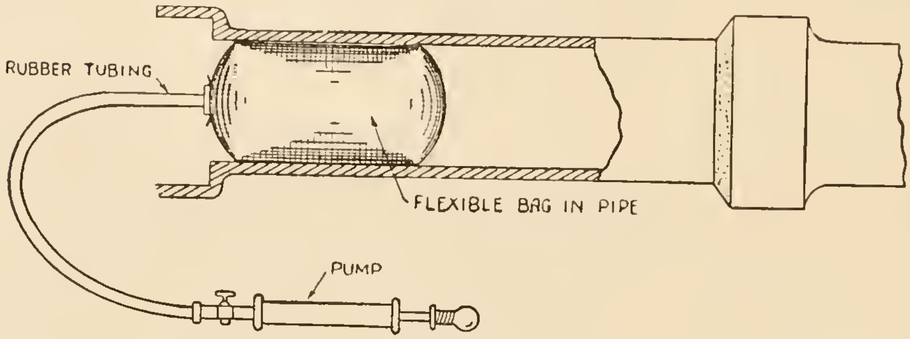


Fig. 70

Drain Tests.—Before the trench containing the drain is filled in, the drain itself should be thoroughly tested.

Various devices have been brought out for this purpose, as, for example, *smoke rockets,* which when ignited are placed in the terminal end of the drain, and the aperture then plugged. The commonest and most satisfactory methods of testing, however, are the pneumatic, hydraulic, and smoke tests, and we will now consider these in the order named.

The **Pneumatic** or **Air Test** consists in sealing up the ventilating shaft or shafts of drain, seeing that all traps are charged with water, and then applying air under pressure at a point—say the intercepting trap near the sewer. When the drain has been pumped full of air, the gauge on the pumping apparatus should show the same reading after the test has been kept on for some time.

The **Hydraulic** or **Water Test** may be said to be the real test for drains. Some hold that it is really too great a test, but when one remembers that should a choke occur and the drains stand full of water, then indeed the necessity for a water test will have been proved. In carrying out this test, we first seal up the drain at that point where the interception trap to the sewer is intro-

duced. The water in the trap is first drawn off, and the pipe sealed either by means of Jones' drain stopper (Fig. 70), or by means of Jones' screw expanding stopper (Fig. 71).

Then the drain is filled with water until it reaches the level of the highest trap on the system. If the water remains at this same level for about an hour, it may be safely said to be satisfactory.

Where the drain has been filled in, or this test is being applied to an old drain, considerable difficulty may arise—if the water in the testing trap subsides—in tracing where the leakage is, and in that case the drain must be tested in sections.

Before leaving this matter of the water test, we might give a short description of the apparatus mentioned in connection therewith. First then, Jones' drain stopper consists of a cylindrical

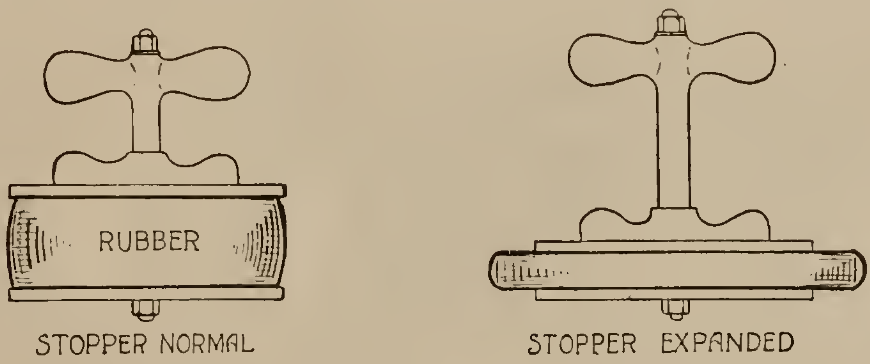


Fig. 71

bag, of coarse canvas, to one end of which is attached a length of tubing with a screw coupling and turncock. By means of a pump which fits this screw coupling, air is pumped into the bag, inflating it so that it fills in the whole inside area of the pipe. These bags are made in different sizes to fit the varying sizes of drains.

In the expanding screw stopper, we have a hollow ring of rubber contained within two galvanised iron plates, the whole being actuated by a screw, which, bringing the two plates close together, expands the rubber and so forces it to fit tightly around the pipe. Now, these stoppers are made in all the necessary sizes for different types of drains.

Before proceeding to describe the third test, let us briefly describe the apparatus in what is known as the smoke machine (Fig. 72). This consists of a strong wooden frame in which are encased a double-action set of bellows which communicates with a cylinder in which smoke is generated by burning oily cotton waste, and from which the smoke is carried by the corrugated flexible pipe to the drain.

Round the cylinder containing the oily waste is an outer casing containing water which supports a dome or float, thus

keeping the smoke from escaping except by means of the pipe leading to the drain.

Having lit the waste, a few short strokes of the bellows handle quickly sets it going ready for the test. The dome or float is then put into position, when we are ready to proceed with the *smoke test.*

Having extracted the water from the trap at the lowest point of the drain, we have the flange at the end of the rubber hose on the machine inserted in position in the drain ; to make it more secure, the flange may be backed with some puddled clay. The smoke is now pumped into the drain by operating the lever on the top of the bellows. All ventilation shafts are plugged, and the smoke ought to be confined within the drain. After a time, the

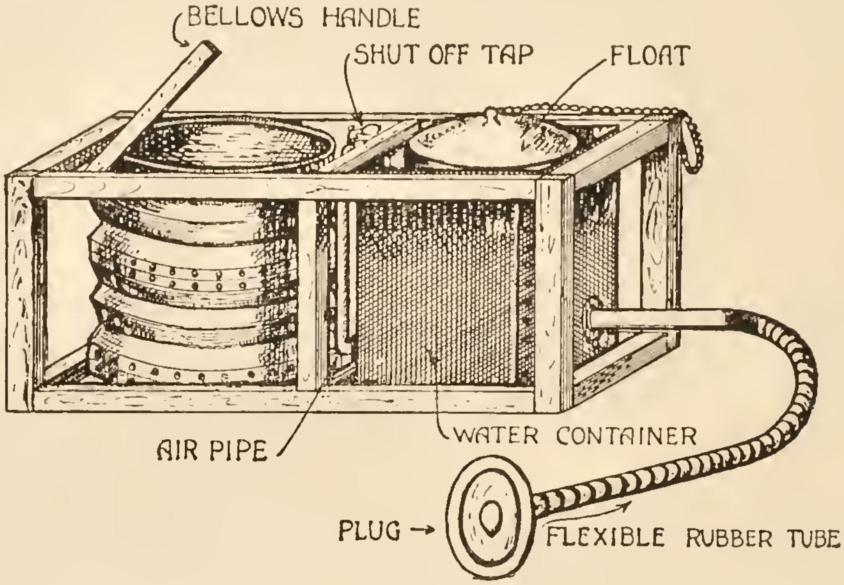


Fig. 72

pumping of the smoke into the drain will cause the drum over the waste cylinder to rise and float in the water around this cylinder. By turning a bypass tap in the middle of the machine, the smoke is now confined to the drain and the machine, and if the float remains in its raised position for a reasonable time then the drain is satisfactory.

One or two points that are worth noting in connection with an examination of the machine before the test are :—

1. See that the chamber contains plenty of waste.
2. See that the container for the water is fully charged.
3. Place the float in position so that nothing will impede its rising.

This machine gives a great deal of satisfaction, and can be used where other tests would be difficult to carry out, such as with waste pipes, soil pipes, etc.

If from any reason a satisfactory test is not obtained over the whole system, then the test must be done in sections, and in this way the fault discovered.

Many other kinds of tests are spoken of, such as the oil of peppermint test, etc. We will, however, deal more fully with these later in connection with sanitary fittings.

All drains are led into cesspools, tanks for the treatment of sewage, or into sewers. The materials used in the construction of *sewers* are silicated stone, brickwork, concrete, iron, or earthenware glazed pipes.

"Silicated stone" pipes are machine-made stoneware pipes which are treated with a bath of silicate of soda.

They do not warp with the heat, and are not liable to fracture lengthways. They are easily jointed, and the inside of the pipes is perfectly true and smooth; the one section fits easily into the other, and the joints are made of Portland cement. These pipes can be used up to a diameter of 42 inches, whereas glazed stoneware pipes must not be used of greater diameter than 18 inches. Brickwork sewers may be made either circular or egg-shaped; the invert or bottom of the brickwork sewer is composed of terracotta, concrete, or glazed stoneware. Concrete sewers generally consist of one part Portland cement, two parts sand, and three parts of small broken stone. The inside must be rendered smooth with cement. Cast-iron pipes coated with Dr. Angus Smith's solution make very good sewers, especially in parts of the ground likely to be subjected to much pressure.

In applying a sewerage scheme to a district, care must be taken to ensure that the sewers are laid at a depth sufficient to drain cellars and basement flats of any buildings in the area, also that the gradients are such that they will give a sufficient cleansing flow, while it is important to see that while the sewer is not too large, it is of a diameter sufficient to take all the sewage of the area at any given time.

Sewers ought to be laid in straight lines as far as possible, and manholes provided every hundred yards, the most convenient sites for these being where tributary sewers join, and, of course, wherever the sewer has to alter its direction a manhole ought also to be built.

The preparation of the trench for sewers, while on a more extensive scale perhaps, is the same as that for drains, and the joints are also made in a similar manner.

All sewers must be ventilated, as air currents are produced by the rise and fall of the sewage, the direction and force of the wind, the difference in temperature of sewer and outside air, floods and flushing, especially if the latter be of hot water.

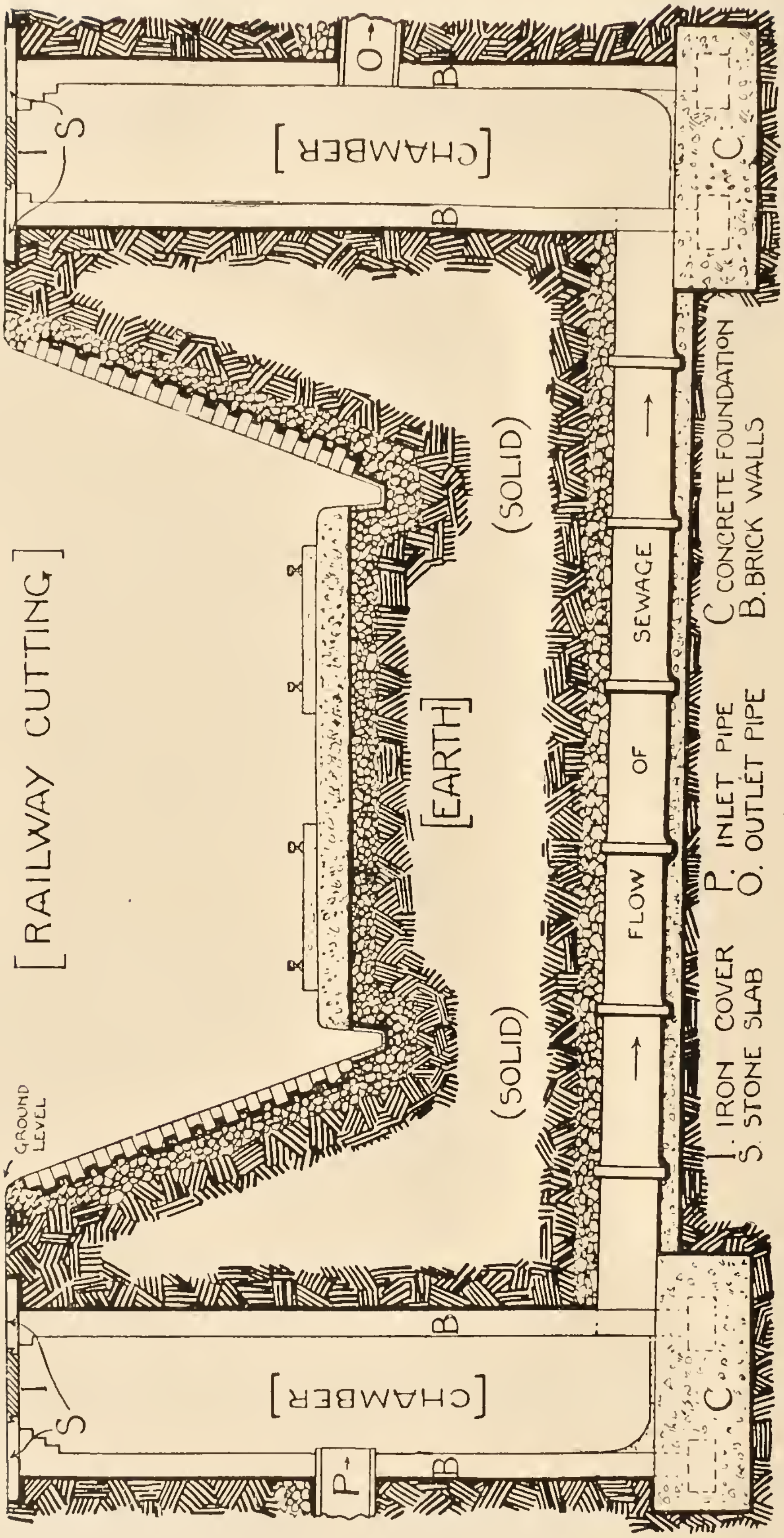

RAILWAY CUTTING
GROUND LEVEL
EARTH
(SOLID)
(SOLID)
CHAMBER
CHAMBER
FLOW OF SEWAGE
I. IRON COVER
S. STONE SLAB
P. INLET PIPE
O. OUTLET PIPE
C CONCRETE FOUNDATION
B. BRICK WALLS

Fig. 73

The methods of ventilation in sewers are by a ventilation shaft at the highest point of the sewer, by manholes, lamp holes, air shafts, special shafts connected to furnaces, extraction fans, and special ventilation shafts to lamp posts; while there is the **Shone Altus System,** which consists of a special inlet shaft at the highest manhole and outlet shafts at the lower manhole on the system, a current of fresh air being drawn along the sewer by means of the escape of compressed air, which may or may not be used to force the sewage.

It often happens that the sewer in its course has to cross a

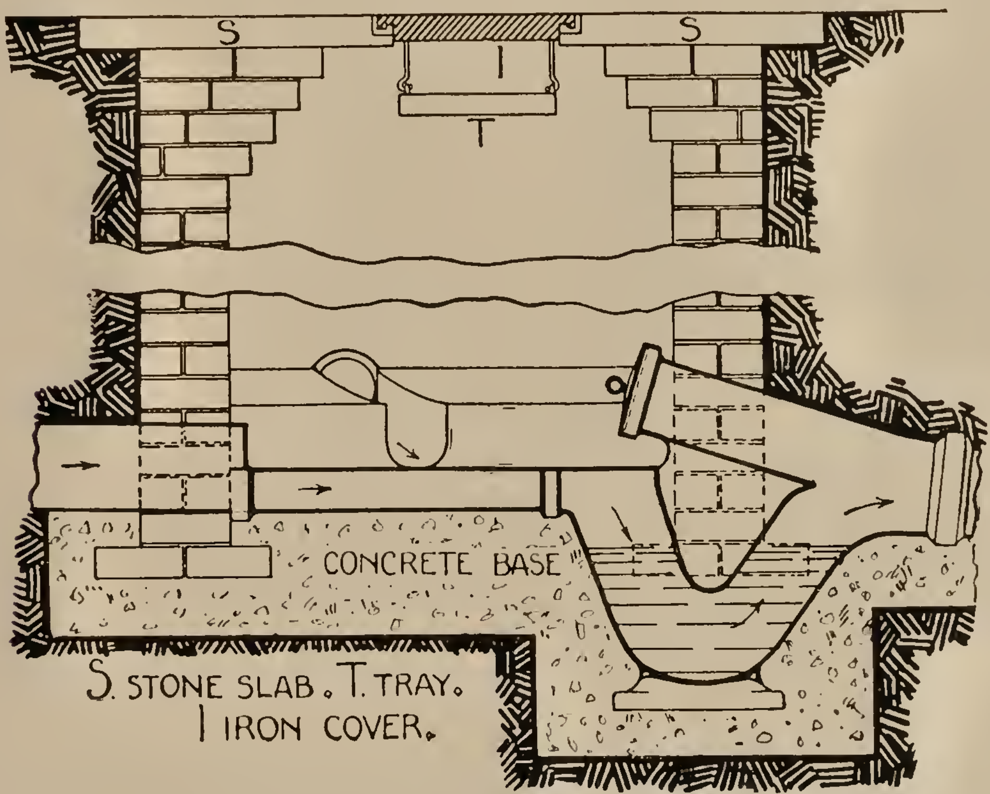


Fig. 74

railway or canal. Under these circumstances, if the sewer is of brickwork, cement, or silicated stone, the method adopted is as shown in Fig. 73. Here two brickwork wells, one on each side of the canal or railway, built in cement and coated on the exterior with puddled clay, are carried to a distance well below the bottom of the obstacle in the way, and joined by a sewer of like diameter to that already entering the well on the one side. The sewage thus passes down one well, along the sewer at the bottom, up the other well, and thence by the sewer leading out of it.

If the sewer be of cast-iron or wrought-iron pipes, the same method is adopted with railways, although with a canal or river they may be laid along the bed of such river or canal.

Manholes are constructed of brickwork built in cement.

The tributary drains enter with an easy bend, and are terminated with channel bends embedded in the cement concrete of the floor of the manhole. Each channel is curved in such a fashion as to prevent splashing by the incoming sewage,the sewer itself, it need hardly be stated, being of course carried through the manhole with channel pipes. Figs. 74 and 75 show both a section and plan of a manhole. The floor of the manhole—which should be laid with cement concrete—should be raised some inches above the channel pipes to prevent sewage from overflowing on to the

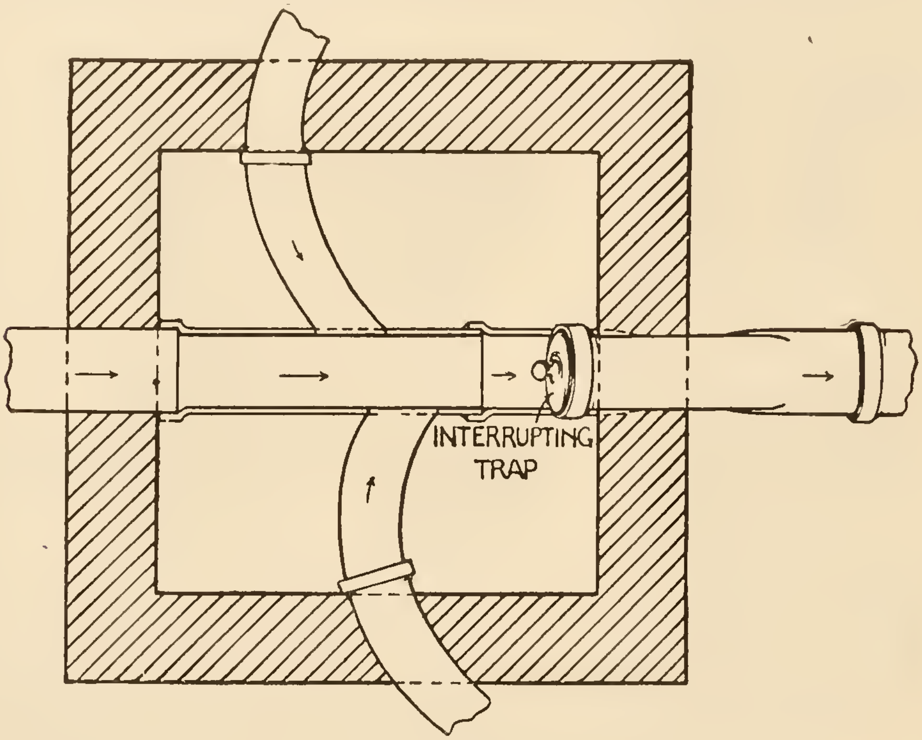


Fig. 75

floor of the chamber, and it should be "floated" with cement so as to give a smooth surface.

All manholes ought to be fitted with perforated iron lids of sufficient strength to withstand any weight passing on top, the idea for the perforated lid being of course to admit fresh air freely.

To prevent any rubbish falling into the manhole through the perforations of the cover, a tray is usually suspended immediately underneath the cover, as defined on the sectional drawing in Fig. 74.

Now, sewers come more within the scope of an engineer's duties, but the brief treatise here given on them will be found of great advantage should any trouble arise in connection with one at any time.

In closing this subject, it might be pointed out that all surface water from streets and footpaths is drained into the sewer direct.

At regular intervals along the sides of the street one will find gratings set in the channels of the road; under these gratings are the gullies or gully traps, and as one often has to deal with complaints of smells from these, it may be well to remark on their construction.

In many districts, the gully consists of a brick-built box, the branch drain from the sewer finishing with an inverted bend pipe to form a trap or water seal. Another method is to employ stone slabs instead of bricks for the sides, the drain connection being

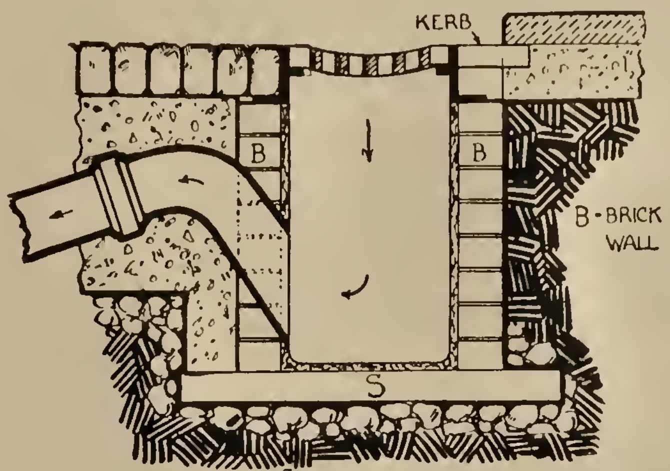


Fig. 76

made in the same way (see Fig. 76). In both cases, the bottom of the gully is finished in cement. The third and best type of gully traps is what is known as **Crosta's Patent Gully,** which is made of cast iron and moulded in one piece, except for the grating.

The great drawback with all gully traps is that in warm weather evaporation of the water they contain takes place, and as a result the trap becomes unsealed and sewer gas escapes, giving rise to complaints of offensive odours.

It is important, therefore, that in warm weather precautions be taken to see that gullies are flushed with water frequently to ensure that they do not go dry.

Again, as there is always a considerable deposit due to the washings of the street or road being carried into the trap, it follows that they should be cleaned out periodically.

Chapter XI

LAW RELATING TO DRAINS AND SEWERS

We have already noted the definitions as laid down in the Public Health Acts regarding drains and sewers.

Under the Public Health Act, 1875, Sections 13 to 36 inclusive, the following are the principal provisions :—

1st. All existing and future sewers and their belongings, except sewers made by any person or company for profit, or sewers used for draining or irrigating the land under any local or private Act, or sewers under the authority of any Commissioners of sewers appointed under the Crown, shall be under the control of the Local Authority. (*Sec.* 13.)

2nd. The Local Authority may purchase any sewers, but the former owners of them shall be entitled to a right to use them. (*Sec.* 14.)

3rd. No Local Authority must create any nuisance in making, maintaining, or altering sewers. (*Sec.* 15.)

4th. Where it is necessary to carry any sewer under any road, street, cellar, vault, etc., the Local Authority may do so after giving reasonable notice of their intention. (*Sec.* 16.)

5th. Before discharging into any natural stream or water-course, canal, pond or lake, the Local Authority must take steps to purify such sewage. (*Sec.* 17.)

6th. Local Authority may alter the size of existing sewers or may discontinue, close up, or destroy such sewers, provided a sewer is available for the use of any person having the use of the sewer to be discontinued, and provided also that no nuisance is created in doing such work. (*Sec.* 18.)

7th. All sewers must be properly covered, ventilated, cleansed, and emptied so as not to be a nuisance. (*Sec.* 19.)

8th. A map of the sewerage system of the district may be provided which can be seen by the ratepayers at all reasonable times. (*Sec.* 20.)

9th. In the case of a house which has no drain within the district of a Local Authority, notice must be given that a drain is to be made and carried into a sewer which is not farther away

from such house than 100 ~~yards~~ feet or into a properly constructed suitable cesspool if the sewer is not within that distance. Power is also given to the Local Authority under this section to fix the nature of the materials, size, gradients, etc., of such drain. (*Sec.* 23.)

10*th.* In any case in an Urban District of a new house or a house pulled down to or below the ground level, and which is to be rebuilt, the Local Authority may require proper drainage, as in Section 23, to be provided, and they may also fix the materials, size, and gradient for such drains. (*Sec.* 25.)

11*th.* No persons may newly build over any sewer belonging to the Local Authority, or build any vault, arch, or cellar over any sewer, unless the consent of the Urban Authority in writing has been obtained. (*Sec.* 26.)

Under *Section* 157, Public Health Act, 1875, *subsection* 4, the Urban Authorities may make byelaws "with respect to the drainage of buildings," etc. The Model Byelaws issued by the Local Government Board on new streets and buildings give the following with respect to the drainage of buildings :—

Byelaw 59 deals with subsoil drainage of all building sites, if such sites are damp. Such subsoil drainage must not communicate with any sewer or cesspool.

Byelaw 60 requires every person erecting a house or building to provide suitable pipes or trunks extending from the roof to the ground, to be fixed to the front or rear or sides of such buildings and connected with gutters, shoots, or troughs for carrying off all water from the roofs or flats of such buildings. This work to be so executed to prevent any dampness in any part of the wall or foundations of such building.

Byelaw 61.—"Every person who shall erect a new building shall construct the lowest storey of such building at such a level as will allow of the construction of a drain sufficient for the effectual drainage of such building, and of the provision of the requisite communication with any sewer into which such drain may lawfully empty at a point in the upper half diameter of such sewer, or with any other means of drainage with which such drain may lawfully communicate.

"Provided that this byelaw shall not be deemed to apply to a cellar intended for storage purposes only, and constructed in a dry soil or so as to be impervious to water."

Byelaw 62.—"(1) Every person who shall erect a new building shall, in the construction of every drain of such building, other than a drain constructed in pursuance of the byelaw in that behalf, for the drainage of the subsoil of the site of such building use good sound pipes formed of glazed stoneware, heavy cast iron, or equally suitable material.

"(2) He shall cause such drain to be of adequate size, and, if constructed or adapted to be used for conveying sewage, to have an internal diameter not less than 4 inches, and to be laid with a proper fall, and with water-tight socketed or other suitable water-tight joints.

"(3) If he shall construct such drain of iron pipes, he shall cause such drain to be properly supported on suitable and sufficient piers or other suitable and sufficient supports, or to be laid in a bed of good concrete.

"(4) If he shall construct such drain otherwise than of iron pipes, he shall cause such drain to be laid in a bed of good concrete.

"(5) He shall not construct such drain so as to pass under any building, except in any case where any other mode of construction may be impracticable.

"If he shall construct such drain so as to pass under any building, he shall cause such drain to be so laid in the ground that there shall be a distance equal at the least to the full diameter thereof between the top of such drain at its highest point and the surface of the ground under such building.

"He shall also cause such drain to be laid in a direct line for the whole distance beneath such building, and if constructed otherwise than of iron pipes to be completely embedded in and covered with good and solid concrete, at least six inches thick all round.

"He shall likewise cause adequate means of access to be provided in connection with such drain at each end of such portion thereof as is beneath such building.

"(6) He shall cause every inlet to such drain, not being an inlet provided in pursuance of the byelaw in that behalf as an opening for the ventilation of such drain, to be properly trapped."

Byelaw 63.—"Every person who shall erect a new building shall provide, within the curtilage thereof, in every main drain or other drain of such building which may directly communicate with any sewer or other means of drainage into which such drain may lawfully empty, a suitable trap at a point as distant as may be practicable from such building and as near as may be practicable to the point at which such drain may be connected with such sewer or other means of drainage.

"He shall provide in connection with such trap proper means of access for the purpose of cleansing."

Byelaw 64.—"A person who shall erect a new building shall not construct the several drains of such building in such a manner as to form in such drains any right-angled junction. He shall cause every branch drain or tributary drain to join in another drain obliquely in the direction of the flow of such drain."

Byelaw 65.—"Every person who shall erect a new building shall, for the purpose of securing efficient ventilation of the several drains of such building constructed or adapted to be used for conveying sewage, comply with the following requirements :—

"(1) He shall provide at least two untrapped openings to such drains, of which openings one shall be as near as may be practicable to the trap which, in pursuance of the byelaw in that behalf, shall be provided between the main drain or other drain of the building and the sewer or other means of drainage with which such drain may lawfully communicate, and on that side of the trap which is the nearer to the building ; and the second opening shall be as far distant as may be practicable from the point at which the first-mentioned opening shall be situated.

"One of the aforesaid openings shall be at or near the level of the surface of the ground adjoining such opening, and shall communicate with the drains by means of a suitable pipe, shaft, or disconnecting chamber.

"The other opening shall be obtained by carrying up a pipe or shaft, vertically, to such a height and in such a manner as effectually to prevent any escape of foul air from such pipe or shaft into any building in the vicinity thereof, and in no case to a less height than ten feet.

"Provided always, that the soil pipe of any water-closet, in every case where the situation, sectional area, height and mode of construction of such soil pipe shall be in accordance with the requirements applicable to the pipe or shaft to be carried up from the drains, may be deemed to provide the necessary openings for ventilation which would otherwise be obtained by means of such last-mentioned pipe or shaft.

"(2) He shall cause every opening provided in accordance with the arrangements hereinbefore specified to be furnished with a suitable grating or other suitable cover for the purpose of preventing any obstruction in or injury to any pipe or drain by the introduction of any substance through any such opening. He shall, in every case, cause such grating or cover to be so constructed and fitted as to secure the free passage of air through such grating or cover by means of a sufficient number of apertures of which the aggregate extent shall be not less than the sectional area of the pipe or drain to which such grating or cover may be fitted.

"(3) Every pipe or shaft which may be used in connection with the arrangements hereinbefore specified shall be of a sectional area not less than that of the drain with which such pipe or shaft shall communicate, and not less in any case than the sectional area of a pipe or shaft of the diameter of four inches.

"(4) No bend or angle shall (except where unavoidable)

be formed in any pipe or shaft used in connection with the arrangements hereinbefore specified.

"(5) Provided always, that where a water-closet shall be constructed so as not to have any internal communication with any building, and where the distance between the water-closet and the trap which, in pursuance of the byelaw in that behalf, shall be provided between the drain with which such water-closet communicates with the sewer or other means of drainage into which such drain may lawfully empty, shall not be more than ten feet, or shall be more than ten feet and not more than thirty feet, the following provisions shall have effect, that is to say :—

"(*a*) Where such distance shall be not more than ten feet, the requirements of this byelaw shall not apply to the case.

"(*b*) Where such distance shall be more than ten feet but shall not be more than thirty feet, an opening shall be obtained by carrying up from a point in the drain with which the water-closet communicates, as far distant as may be practicable from the trap, which, in pursuance of the byelaw in that behalf shall be provided between such drain and the sewer or other means of drainage into which it may lawfully empty, a pipe or shaft vertically to such a height and in such a manner as effectually to prevent any escape of foul air from such pipe or shaft into any building in the vicinity thereof, and in no case to a less height than ten feet, and such pipe or shaft shall be of a sectional area not less than that of the drain with which it may communicate, and not less in any case than the sectional area of a pipe or shaft of the diameter of four inches."

Byelaw 66.—"A person who shall erect a new building shall not construct any drain of such building in such a manner as to allow any inlet to such drain (except such inlet as may be necessary from the apparatus of any water-closet or any slop sink constructed or adapted to be used for receiving within such building any solid or liquid filth) to be made within such building."

"He shall cause the soil pipe from every water-closet in such building to be at least four inches in diameter.

"He shall cause such soil pipe and the waste pipe from every such slop sink to be fixed outside such building, and to be continued upwards without diminution of its diameter, and (except where unavoidable) without any bend or angle being formed in such soil pipe or waste pipe to such a height and in such a position as to afford, by means of the open end of such soil pipe or waste pipe, an outlet for foul air, at a safe distance from windows, chimneys, and other openings.

"He shall so construct such soil pipe that there shall not be any trap between such soil pipe and the drains or any trap (other

than such as may necessarily form part of the apparatus of any water-closet) in any part of such soil pipe.

"He shall also cause the waste pipe from every bath sink (not being a slop sink constructed or adapted to be used for receiving any solid or liquid filth) or lavatory and every pipe in such building for carrying off foul waste water to be properly trapped and to be taken through an external wall of such building and to discharge in the open air over a channel leading to a trapped gully grating.

"He shall cause the overflow pipe from any cistern, and from every safe under any bath or water-closet to be taken through an external wall of such building to discharge in the open air."

In the foregoing, we have taken the Model Byelaws verbatim, because they are indeed a good lead in what one must understand with regard to drainage.

Provisions are made in these byelaws for the proper drainage of wet sites, the nature of the pipes used for all drainage, size of drains, the conditions where drains pass under buildings, trapping of drains, junctions with drains, ventilation of drains, etc.

Under the Public Health Act, 1875, Section 41, it is stated that on the written application of any person to a Local Authority complaining of a nuisance from any drain, water-closet, earth-closet, privy, ashpit or cesspool, the Local Authority may empower their surveyor, after twenty-four hours' written notice to the occupier of such premises, or in cases of emergency without such notice, to enter such premises with or without assistants and cause the ground to be opened and examine such drain, etc.; and if he find that such drain, etc., is in good condition he shall cause the ground to be closed, any damage done to be made good, and the expenses defrayed by the Local Authority. But if the drain, etc., be in bad condition, the Local Authority shall give notice in writing to the owner or occupier requiring him within a reasonable time to do the necessary work, and if such person does not comply with the terms of the notice, he shall be liable to a daily penalty of 10s. for every day of default.

This section is further extended by Section 19 of the Public Health Acts Amendment Act, 1890, which deals with the case of two or more houses belonging to different owners and connected to the public sewer by a single branch drain. In this case the Local Authority may recover any expenses incurred by the foregoing section, the different shares of the account to be allocated by the surveyor, or in case of dispute by a court of summary jurisdiction; or such expenses may be declared by the Local Authority to be deemed private improvement expenses and paid by them as such.

Again, for the purpose of this section the expression drain includes a drain used for the drainage of more than one building.

In the law relating to Scotland on this subject, we find in the Public Health (Scotland) Act, 1897, Section 101, that all sewers within a district are to be vested in the Local Authority of that district, special provision being made with regard to the rights of any persons who own or manage any sewers under local or general police statute.

In Section 102, powers are given Local Authorities to purchase sewers and acquire the rights and powers vested in any person with regard to existing sewers, while in Section 103, powers are given Local Authorities to make sewers; proper attention to be given to construction, maintenance and cleansing of such sewers and the treatment of sewage before passing into any noir or stream. In Section 104, where it is necessary to carry a sewer for purposes of distribution, outfall, disposal, or treatment of sewage outwith the district of any Local Authority, the Local Authority, three months before commencing any work under the provisions of this Act outwith their own district, shall give notice of their intentions in the newspapers circulating in the district or by handbills, such notice to describe the nature of intended work, the names of the parishes, streets, roads, etc., which sewer is to pass over or under, and shall name a place where a plan of the intended work is open for inspection at all reasonable hours; a copy of the notice to be served on all owners and occupiers of such lands, and on the Local Authority and County Council of the district through which the sewer is to pass. All objections, *which must be in writing*, to be lodged with the Local Authority within the specified three months. Work shall not be commenced without the sanction of the Local Government Board after inquiry.

In Section 107, Local Authorities have powers to carry sewers under or across railways, etc., by arrangement with railway or canal company's engineer.

Penalties are inflicted in Section 112 on persons making drains without authority.

Persons are prohibited from building over sewers, unless with the consent of the Local Authority, Section 114.

Section 115 requires all sewers and drains to be properly trapped, while it is a punishable offence under Section 117 to interrupt the free flow of sewage in any drain or sewer by allowing anything to pass into such drain or sewer likely to cause an obstruction.

Under Section 120, the Local Authority can compel an owner to drain his property. If such property is within 100 yards of a public sewer, such drain shall discharge into the sewer, but if there

is no sewer within that distance, then the drain shall empty into a properly constructed cesspool or other place, not being under any house. The Local Authority shall serve a notice requiring such work to be done, and if such owner does not do the work in the time specified, then the Local Authority may do the work and the expenses incurred in so doing recovered in a summary manner.

Local Authorities may combine to provide a scheme of sewerage for their districts, *vide* Section 121, while if requisition is made by a Parish Council or ten ratepayers of a district under Section 122, the Local Authority may meet after twenty-one days' notice and form special drainage districts. Going back to the Nuisance Section of the Act, Section 16, subsection 2, we find :—

"Any street, pool, ditch, gutter, watercourse, sink, cistern, water-closet, earth-closet, privy, urinal, cesspool, drain, dungpit or ashpit so foul, or in such a state or so situated as to be a nuisance or injurious or dangerous to health, shall be deemed to be a nuisance liable to be dealt with summarily in manner provided by this Act." While in Section 30, a penalty is imposed on any person injuring or wilfully damaging any drain, etc.

Under the Burgh Police (Scotland) Act, 1892, Sections 215 to 237, we find that all sewers are vested in the Commissioners or Local Authority, who have power to purchase certain sewers, and without whose consent private sewers or watercourses, etc., are not to be used. They may also form drainage districts subject to the approval of the Sheriff, and construct sewers where none exist. They may also give notice of new levels of sewers, and must not allow sewage to pollute streams. Authorities may from time to time alter existing sewers and, provided they lay down others, they may destroy existing sewers. Penalties are laid down for punishing persons making unauthorised drains. No cellar or vaults are to be made under streets without the permission of the Commissioners. All sewers must be trapped and ventilated. Persons aggrieved by the making, etc., of sewers have power of appeal.

With regard to drains, these are dealt with in Sections 238 to 245 of the Act as under :—

Local Authority, here called the Commissioners, may construct drains charging the owner for same. No house to be constructed without drains, and houses must be so built on a level as to allow of proper drainage. All house drains to be properly ventilated, and all drains and cesspools must be kept in good order by the owners; all such drains and cesspools to be regularly inspected. Penalties are laid down for persons making or altering drains without permission from authority. Any parties aggrieved by any matters regarding drains to have right of appeal to the Sheriff.

Chapter XII

TRAPS

Before proceeding to discuss sanitary fittings in buildings, let us consider the various types of **Traps** one meets with in connection with such work, their suitability or otherwise for the work for which they are intended, and the nature of the fitting with which they are to be connected.

The purpose of traps is to provide a movable barrier so that sewer gas may be prevented from entering any building. For this reason these appliances are so constructed that they retain a certain amount of water which, together with some part of the trap itself, gives a sufficient seal against the sewer gas.

The *depth of a water seal* should be from 1½ to 2 inches—preferably the latter. It must not be too deep, otherwise it would interfere with the free flow of any matter in suspension in the waste products, neither must it be too short, or it will rarely serve the purpose for which it is intended.

Traps, it may be mentioned, although of the proper and requisite depth of seal, may become unsealed in various ways, such as by momentum, syphonage, capillary attraction, waving out, and by evaporation.

Momentum is the weight of a body multiplied into its velocity: thus, if a pail of water be discharged down a water-closet from a height, the force so exerted may be such as will leave the trap unsealed before the balance of water can be re-established.

Syphonage is caused by the removal of the air pressure on the outlet of the trap, the pressure on the inlet forcing the water over the trap until the seal is broken, allowing the air to gain access to the outlet; hence the necessity of providing anti-syphonage pipes, and for efficiently ventilating soil and waste pipes.

Waving out is caused by wind blowing across the top of the pipes. A strong gust of wind may create a partial vacuum in the pipes. Thus the water on the inlet side of the trap is pressed down; when the gust of wind has passed, the water then falls back again, and this motion is sufficient at times to "wave" enough water out of the trap to render its seal useless.

Evaporation.—Traps under fittings that are not in use or are not frequently used, and surface traps in cellars that are seldom if ever used, also outside traps, during a dry season, may become dried up by the water being drawn into the atmosphere by evaporation.

Capillary Action.—Traps may be emptied of the water they contain by fibrous matter having one end amongst the water in the trap and the other end over the outlet, the water being drawn over by capillary action.

It is also necessary here to point out that pressure of foul air inside the drain may displace the water seal in a trap. Now, this possibility can best be guarded against by proper and efficient ventilation of the whole drainage system.

Again, the question is often asked as to whether the foul gases of the drain or sewer can be absorbed by the water on one side of the water seal of the trap, and discharged by the water on the other side. There is no question but that where water stands for any length of time in a trap, as a water seal, such a thing may easily happen, and the remedy is in having traps which have a thorough self-cleansing action, together with good drainage ventilation.

All traps are liable to become choked at times owing to the fact that they must of necessity form a certain amount of obstruction to the flow of sewage. Under these circumstances, it should always be insisted on that traps be so placed that easy access to them is at all times possible.

The chief principles of a good trap therefore are :—

1. Simplicity of construction.
2. Ease of access at all times.
3. Self-cleansing in shape.
4. A water seal of from $1\frac{1}{2}$ to 2 inches.
5. Smooth in the interior and well glazed.
6. Efficiently protected against syphonage.

The commonest types of traps one meets with are intercepting traps, gully and grease traps, D traps, Bell traps, Antill's traps, Dipstone or Mason's traps, and syphon traps. With the exception of syphon and gully traps, the others are more or less objectionable ; but we will now take each type separately, with a view to understanding the difference in manufacture, and how far their individual makes comply with the principles set down.

First, then, of all the many types of disconnecting traps, there are three which we may take as being proved reliable because of their many tests in actual practice.

In Fig. 77 is shown what is known as the **Buchan intercepting trap,** principally used where an inspection chamber is not built

at the point where the drain joins the sewer. As will be seen, the trap stands on a good square base and has a socket to receive the terminal pipe of the drain. A large air inlet is provided, and this is carried up to the level of the ground surface by means of pipes, and covered with a grating. Beyond the water seal of the trap, and on the sewer side, is an inspection eye which may also be carried

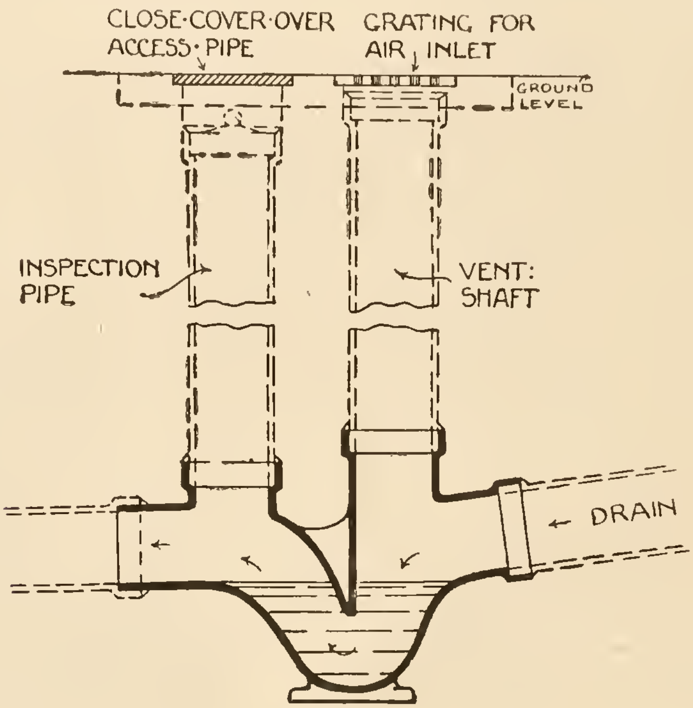


Fig. 77

up to the same level. These traps are made in various sizes, are of glazed stoneware or fireclay, and—in actual practice—if properly fixed, they give every satisfaction.

The second type of intercepting trap is what is known as the **Weaver's Trap,** as seen in Fig. 78. This closely resembles the trap already described, being set on a solid base, and having a good water seal; it is also provided with an air inlet and access eye, both being carried up in the same manner as in the Buchan trap. This trap is also made in fireclay or glazed stoneware, and is very satisfactory. It may also be mentioned that both types of traps may be had in iron for iron drainage.

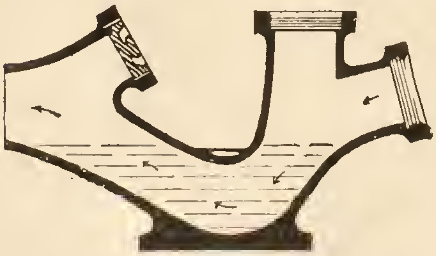


Fig. 78

The third type of disconnecting trap we shall discuss is used in connection with an inspection chamber, and for which certain distinct advantages are claimed; principally that a water test can

be applied to the drains without any apparatus whatsoever. This type of trap, known as **Winser's Intercepting Trap,** is built, as shown in Fig. 79, at the outlet of the drain in the inspection (or disconnecting) chamber. Built into the wall of the chamber is a hook on which are suspended a metal plug and chain. This metal plug fits exactly a recess cut out in the rim of the trap through which the drainage passes. Should a test be required at any

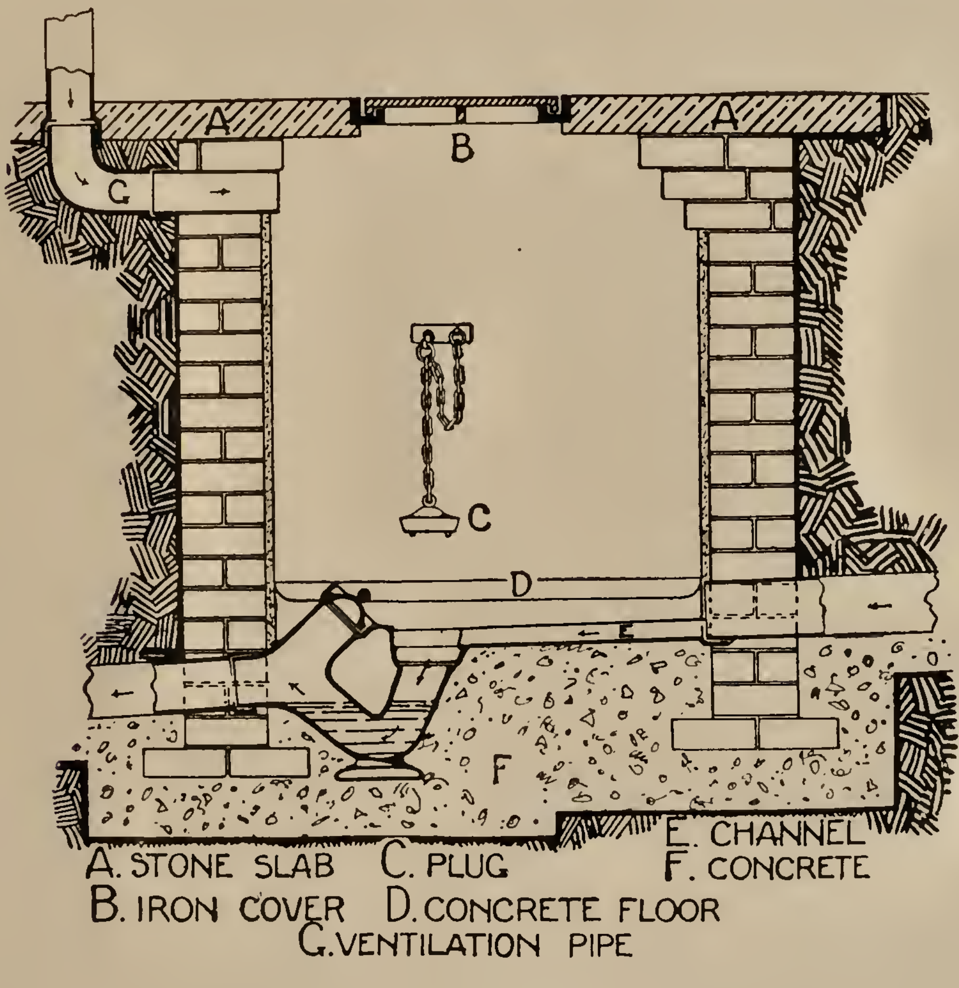


Fig. 79

time, one has simply to place the plug in position on top of the inlet of the trap, and the incoming water, finding its exit barred, will stand back in the drain and remain so, until by pulling on the chain the inlet of the trap is again opened and the plug replaced on the hook of the inspection chamber wall. Of course, the walls of the inspection chamber must be water-tight to prevent the sewage finding its way through, but, as has already been pointed out, we aim at the proper construction of inspecting chambers as a protection against pollution of the surrounding soil owing to choked drains. This trap is also provided with an access plug or inspection

eye, through which rods can be passed should an obstruction take place at any time in the drain.

It should be pointed out here that with traps provided with inspection eyes, these should be kept closely covered when not being used.

Dealing now with **Syphon Traps,** one finds in use in drains a type consisting of an ordinary pipe with a bend in it, as shown in Fig. 80. A study of the drawing will at once show some important drawbacks in connection therewith. In the first place, there is no base on the pipe, and consequently the risk of its being fixed out of position is very probable. In the second place, the depth of water seal is insufficient. In the third place, there is no means of access to the trap should a choke occur in it; and fourthly, no provision is made for ventilation in the shape of an air inlet on the drain side of the trap. To sum up, this type of trap is objectionable and its use should never be allowed.

Fig 80

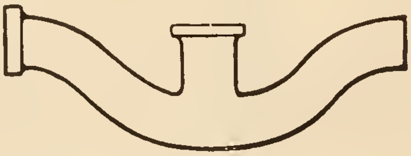


Fig. 81

In Fig. 81 we have a modification of the trap we have just been discussing. Here an attempt has been made to provide an inspection eye or means of access should a choke occur, but it will readily be seen that this intended improvement is of little use, as it is always a difficult matter to use this access to assist in clearing the drain; and again, solid matters in suspension are liable to find a resting place in this recess and so cause trouble.

We now come to the type of traps known as **Gully Traps,** used for cutting off the various house waste pipes such as wash-hand basins, sinks, rainwater pipes, etc., from direct communication with the drain.

Again, gully traps are used to take off surface water from paved passages and yards, while they are also used in connection with coach-houses and garages to carry off swillings and water used for cleansing and flushing purposes. They are also used for carrying off the liquids from stables, cowsheds, and piggeries, also for the reception of certain liquid wastes in connection with manufacturing processes.

Under no circumstances, it is said, should a gully trap be fixed inside a house, and this fact ought always to be kept in mind and enforced, although a case sometimes arises in connection with the drainage of the floor of a cellar, where it is impossible to do otherwise than allow a gully trap to be introduced into the house

or building, but in a case of this kind it will be sufficient to deal with the individual case on the merits it presents.

Indeed, we shall come shortly to the legal aspect of the case with regard to traps, where we shall see that clear, clean cut regulations are laid down to govern their proper position with regard to the use they serve.

We have already noted the types of gully traps used in roadways for taking the surface water.

The ordinary gully trap used for waste water is that shown in Fig. 82. This trap is made either in fireclay or iron, and is self-cleansing. It is covered with a barred grating let into a "basinstone" on top of the trap, the waste pipe discharging over the grating. Let us look for a minute here at the Model Byelaws as framed by the Local Government Board, in No. 66, paragraph 4, which deals with gully traps and which states:—

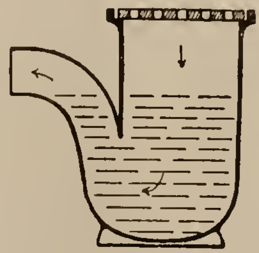


Fig. 82

"He shall cause the waste pipe from every bath, sink (not being a slop sink constructed or adapted to be used for receiving any solid or liquid filth), or lavatory, the overflow pipe fron any cistern, and from every safe under any bath or water-closet, and every pipe in such building for carrying off waste water, to be taken through an external wall of such building and to discharge in the open air over a channel leading to a trapped gully grating at least 18 inches distant."

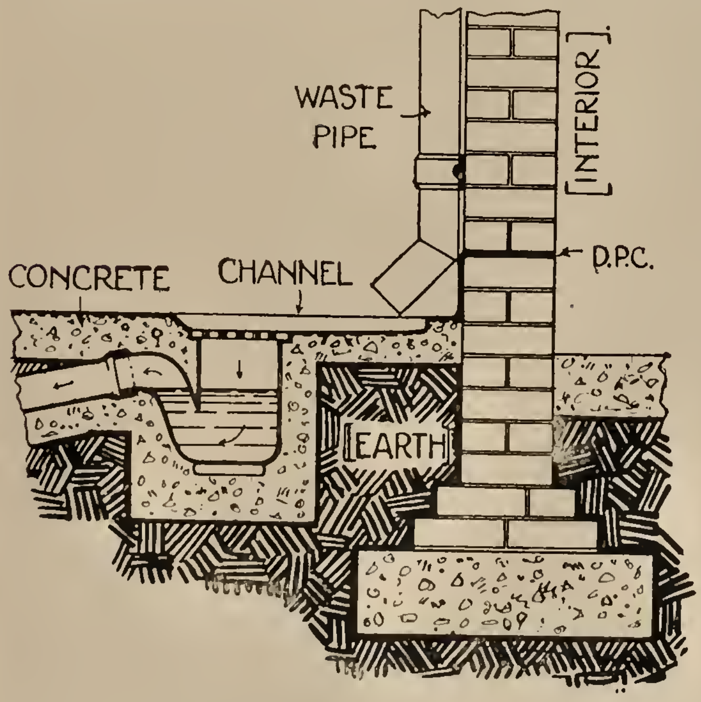


Fig. 83

Under these circumstances, then, the gully would require to be constructed as shown in Fig. 83. In practice, however, one finds this byelaw considerably modified except in buildings where something approaching the ideal is aimed at. One usually finds that the pipe coming down the wall has an offset at the bottom to direct the water forward so as to discharge over the trap grating a few inches away, and in many cases the pipe is carried below the

ground level and connected direct to the trap by means of an opening (known as a back inlet), provided for the purpose as shown in Figs. 84 and 67, while in some cases traps are made with connections to take two waste pipes in a similar fashion.

Sediment in gully traps often causes a good deal of trouble, and for this reason a type of gully trap is on the market which is constructed with a sediment pan as seen in Fig. 85. By this means, it is quite a simple matter to remove the grating and lift out

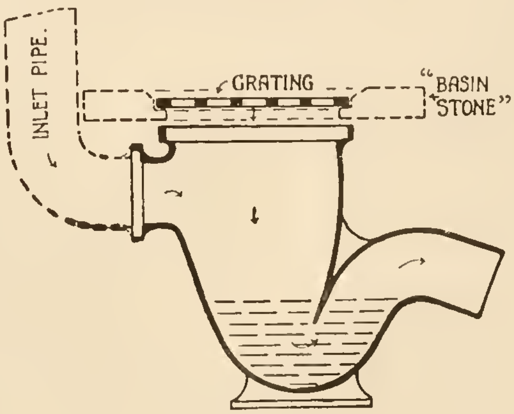


Fig. 84

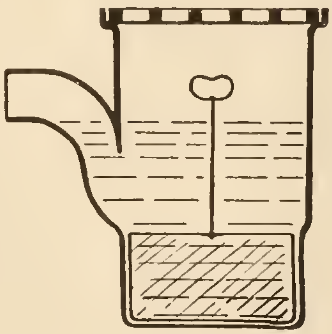


Fig. 85

the pan for cleaning purposes. This type of trap saves a good deal of trouble when used for the drainage or surface water of a yard.

The type of gully trap which gives most trouble is that used in connection with any waste pipe conveying water which contains large quantities of fatty matters, such as from sinks in kitchens, etc. For this purpose, special fat or sediment traps have been introduced of which that shown in Fig. 86 is a type; the idea was to cool and solidify the grease and fat in the central part of the trap. This necessitated the periodic removal of the cover *A*, and the breaking of the solid mass in order to keep the trap clear. As a rule, this type of trap became so neglected that it proved practically useless. Its construction debarred it from being self-cleansing in its action, and on the whole it proved in practice to be a disgusting and obnoxious form of grease trap. The only form of grease traps that are permissible are those which are of self-cleansing shape and which have an opening in their rim for flushing purposes. Such a trap has an automatic flushing tank connected with it by means of a pipe which enters the trap at the opening mentioned in the rim of the gully.

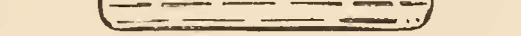


Fig. 86

Let us now take a few of the older types of traps one often meets with, so that we may be familiar with them should we have to deal with them.

One of the oldest is that known as the **Mason** or **Dipstone Trap.** As its name implies, it consists of a box built in masonry or brickwork, having its interior divided into two compartments by means of a stone slab set transversely across it, and built in such a way that 2 or 3 inches of this stone slab are under the surface of the water, thus giving a water seal. Looking at the Fig. 87, we can see at a glance that such a trap is not self-cleansing, being squarely built. Again, these traps are usually much too large in size, and, being square, the corners soon contain large quantities

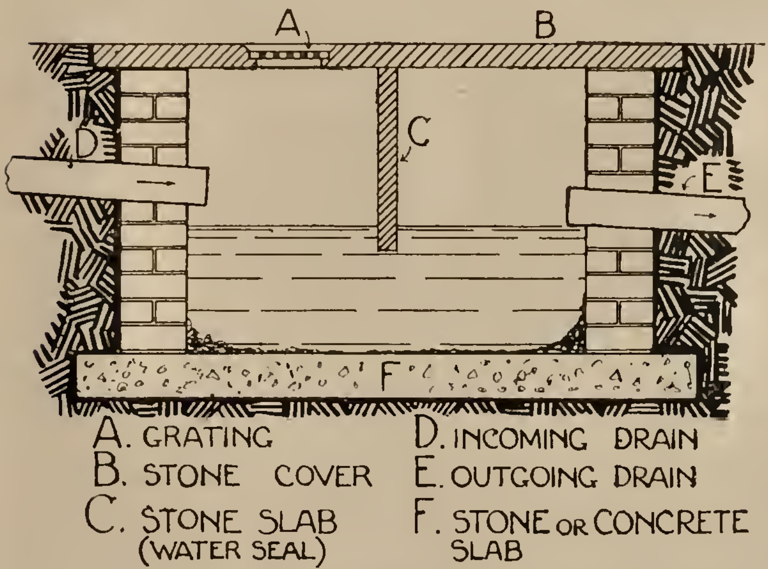


Fig. 87

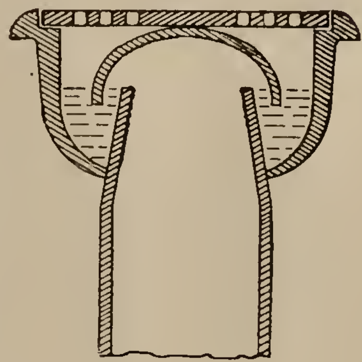


Fig. 88

of putrefactive filth. The stone which is alleged to be the water seal may certainly serve that purpose at the point where it is in the water, but the upper edge of this stone is usually of so rough a nature and no attempt made to make a joint of it with the cover, that sewer gases have no difficulty in passing over the top, so that there is no water seal. Such a trap, therefore, is useless and only a source of trouble.

The next trap we will consider is that favourite of many examiners, namely the **Bell Trap,** seen in Fig. 88.

Until quite recently one found many traps of this type fixed inside sculleries, etc. In this trap one usually finds that the depth of the water seal is only about half an inch at most, and very often a good deal less. The space between the bell and the end of the pipe is usually very small, and as a consequence such a trap is very liable to choke. The trap itself is usually of iron, and may be said to consist of two pieces, viz. a pipe with a cup arrangement around

in which is the container for the water, and which is finished at the top with a recess to take the grating. This grating forms the second piece of the trap, and on the underside of it is cast a bell, from which the trap takes its name. When in position, this bell may be said to fit loosely over the outlet pipe of the trap. This trap is very objectionable for many reasons, chief among them being the following:—1st, the trap is not self-cleansing; 2nd, in the space between the bell and the outlet of the trap chokages easily occur, thereby necessitating the lifting of the trap cover and with it the bell, thus resulting in the drain becoming unsealed and sewer gas passing into the apartment; 3rd, owing to the shallowness of the water seal, the least evaporation causes the trap to become unsealed; and 4th, it is the exception—rather than the rule—to find the bell of the trap intact. We most often find that the bell has been broken off, and thus the trap is useless. For these and many other reasons, the bell trap ought to be, and is, condemned.

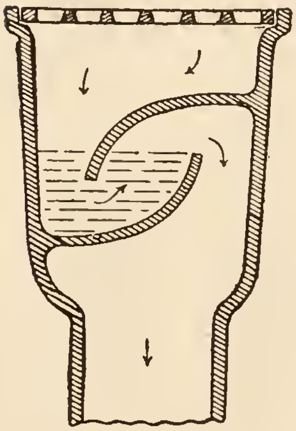


Fig. 89

In Fig. 89 we have what is known as the **Antill's Trap.** This trap is not self-cleansing, but is a big improvement on the bell trap, although it is very liable to accumulate a deposit in that part of the trap forming the container for the water.

So much then for those traps which one often finds in connection with drains. There are other types, of course, to be met with, much less common, but a general knowledge of those dealt with will keep the student right in any questions on the subject, especially if he remembers the requirements with which a good trap must comply, and also if he remembers that in the list just gone over, the intercepting traps given and the self-cleansing gully traps are really the only ones which may be said to be in any way admissible.

We will now consider traps as used in connection with other sanitary fittings, as in this way we will find the study of sanitary conveniences much more simple when we come to deal with it later.

In the D trap defined in Fig. 90, an old method is shown which is often met with still, in connection with old-fashioned water-closets. It is a very objectionable form of trap; having too many corners, it is not self-cleansing, and the large flat surfaces together with its too numerous corners are in direct opposition to what is required in a trap, while the large space above the water surface becomes charged with very offensive odours. Altogether, this form of trap can never be satisfactory, and ought to be condemned.

Let us now consider the various traps which are fitted in connection with sinks, baths, washhand basins, etc.

These traps, which are usually of drawn lead or iron, except in cases where they are cast (each) in one piece with the fitting they serve, are often known by alphabetical names, such as D, P,

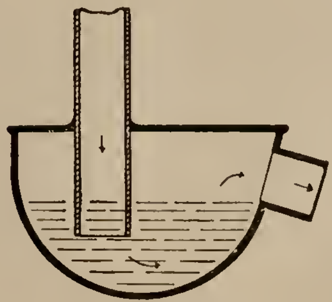


Fig. 90

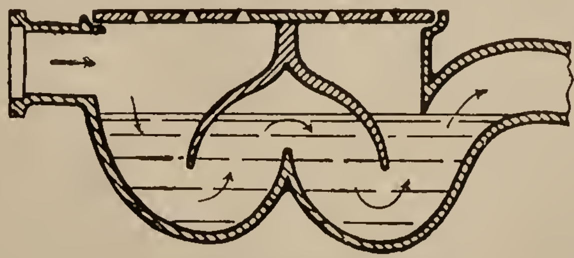


Fig. 91

Q, S, U, V, and W, because of the resemblance they bear to these letters.

The D trap we have already considered ; the U trap is the bent syphon pipe trap ; and the W is a grease-box trap after the type shown in Fig. 91.

The P trap is made of drawn lead or iron, and is fitted with lavatories, baths, and sinks. It is fitted with an access plug at the bottom to facilitate cleansing of the trap periodically, which is always highly desirable. Beyond the water seal of this trap, an inlet for an antisyphonage pipe is provided. (Fig. 92.)

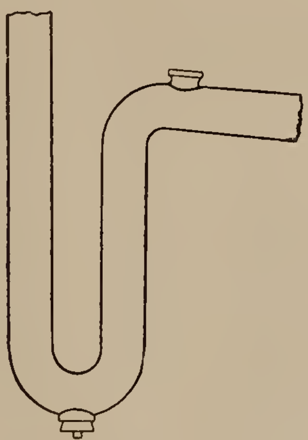


Fig. 92

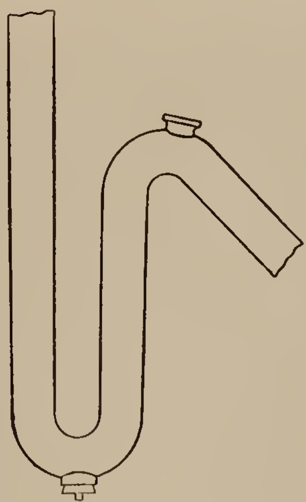


Fig. 93

The Q trap resembles the P trap, with this difference—that the end of the pipe conveying the waste water is carried down with a greater fall as seen in Fig. 93. This trap is also furnished with an access plug at the bottom and an inlet for an antisyphonage pipe. The Q trap is *also* used in connection with baths, sinks, and lavatories.

Next, we have the S trap as seen in Fig. 94. This is made of the same materials and finished in the same manner as the P and Q traps.

In Fig. 95, we see what is known as the V trap, used principally as a grease trap, but also for trapping waste pipes of sinks and baths, etc.

One other type of trap which is a very good pattern is the Anti-D trap. This trap must not be confused with the objectionable D trap which we discussed previously.

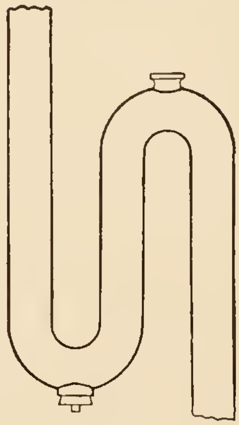


Fig. 94

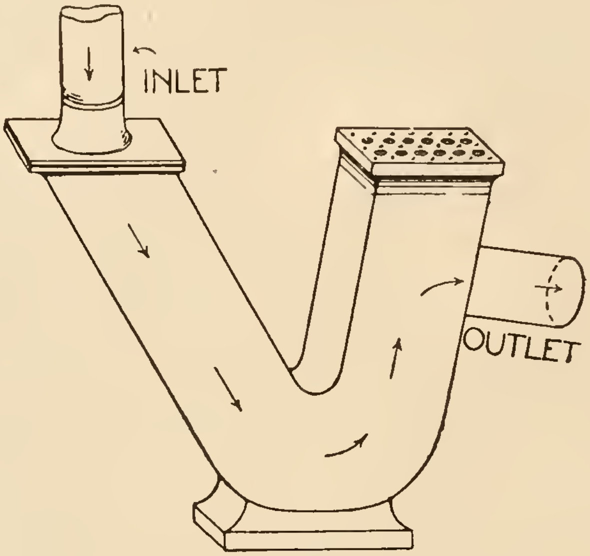


Fig. 95

The Anti-D trap, shown in Fig. 96, was invented by a Mr. Hellyer. It is not only used in connection with baths, but with other fittings as well. Now, it will be observed that the incoming pipe tapers towards that part forming the water seal of the trap, while the outgoing pipe is square in shape and enlarged. Thus, it is claimed that with this kind of trap syphonage is prevented, but while one might not go the length of saying that antisyphonage is absolutely prevented by this type, still the trap has many good points, not the least of which is its self-cleansing nature.

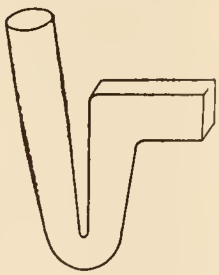


Fig. 96

So much, then, for traps used in connection with drains and sanitary fittings ; but before proceeding to the consideration of how they are fixed with their accompanying "convenience," let us emphasise here the great necessity of taking every available opportunity of studying these at first hand and also of making every effort to know them by name and description. Questions on traps take a prominent place in

examination questions, and it behoves the student to become thoroughly acquainted with them.

In concluding this chapter, it will not be out of place here to consider the construction of tanks used for flushing drains and traps. **Automatic "Flush Tanks"** are excellent appliances, and very necessary, as well as desirable, where drains cannot be given a good fall.

One of the most efficient flush tanks used for the purpose is that shown in Fig. 97 and known as *Field's Automatic Flush Tank.* This type can be had in various sizes, in accordance with the size of the drain or other arrangement to be flushed. It may be worth while pointing out here that tanks of this description are made of

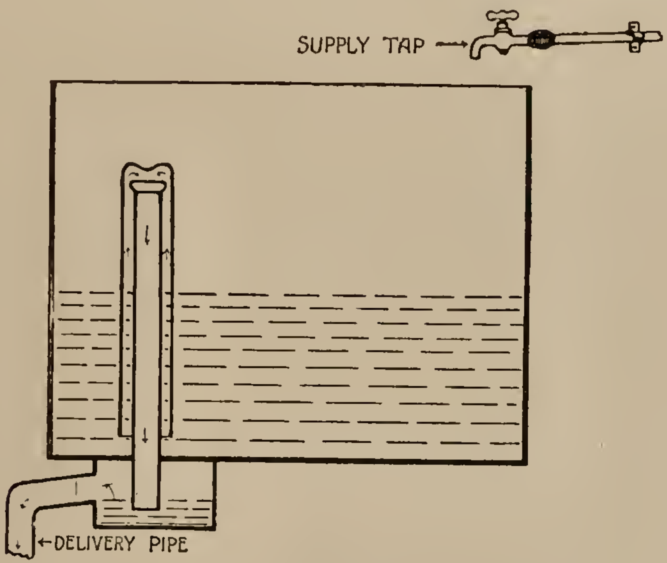


Fig. 97

very large size for flushing sewers, and in such a case the tank is usually built of brick rendered in cement. In the type of tank used for drains or traps, galvanised wrought iron is the material employed, although in many public lavatories and urinals the tank has a framework of copper filled with plate glass to give a more ornamental appearance.

The apparatus, then, consists of an outer tank, and passing through the floor of this tank is a pipe which is open at both ends; the lower end of this pipe terminates in a chamber underneath the main tank, and from this chamber the outlet pipe leads. The upper part of the pipe—passing through the bottom of the tank—is covered with a cap which, however, does not quite reach to the bottom.

A tap connected to a water service pipe is made to discharge over the tank, and the automatic or syphonic action of the apparatus is then as follows :—

As the water from the tap fills the tank, part of the water ascends the annular space between the two pipes inside the tank, and displaces the air inside the pipe passing to the chamber beneath. When the water has reached the top of the space between the two pipes it begins to fall down the central pipe, carrying still more of the air therein with it, and by this process a point is reached when a partial vacuum is created within the pipe ; then the pressure on the surface of the water in the tank forces the water from the tank and into the central pipe ; thus, having started syphonic action, the whole water in the tank is emptied through the outlet pipe of the chamber underneath.

The top of the central pipe is dome-shaped, to encourage syphonic action, as with this modification the water on rising, instead of trickling down the sides of the inner pipe, is caused to fall freely down the centre pipe. This points to a very important detail in fixing these tanks, namely, that care must be taken to ensure that the syphon is perfectly upright. Once syphonic action is started, the tank very soon empties itself. The interval between the periods of flushing is regulated by the amount of water entering from the taps, already referred to, for supplying the apparatus with water.

There are, of course, other types of flushing tanks in use, but the same principle may be said to apply to most of them, and a knowledge of the one described will meet any difficulties that may arise in connection with this matter.

Chapter XIII

WATER-CLOSETS, TROUGH CLOSETS, AND URINALS

HAVING discussed the various types of traps one meets with in connection with drains and sanitary fittings, let us now turn our attention to a study of the various sanitary conveniences, foremost amongst these being water-closets.

We will leave the important matter of fixing the fittings until a later chapter, while we consider here the various designs and merits of the many types of closets one meets with everywhere.

Simplicity of design in this kind of convenience, coupled with antisyphonage arrangements, a good water seal, and as little interruption to the water flush as possible, are the main factors to aim at, but unfortunately one finds closets in use which, because of the very intricate nature of their construction, give rise to a good deal of needless worry and expense.

Among the many makes of water-closets the following list contains many which "crop up" very often:—The valve, the plug, the pan, the long hopper, the short hopper, the trapless closet, the wash out, and the wash down; and we will now take these in the order in which we have set them down, and discuss their construction, merits, and demerits for the purpose for which they are intended.

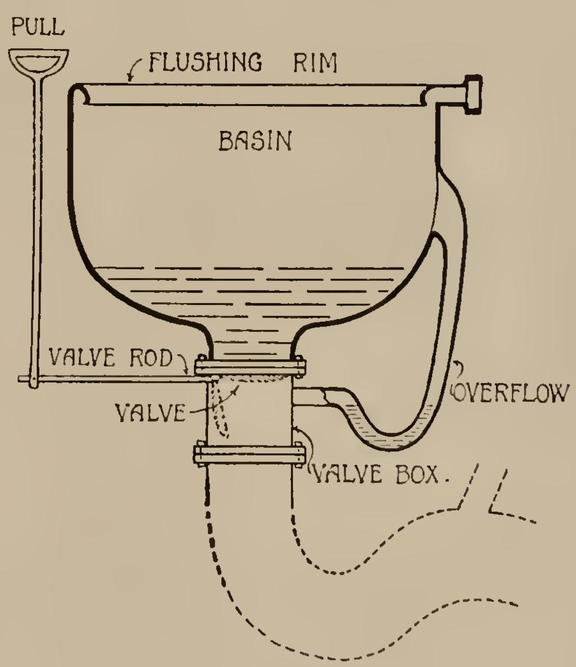


Fig. 98

The **Valve Closet,** as shown in Fig. 98, consists of an earthenware enamelled basin fitted on top of a metal valve box. This box, which is usually of cast iron, is enamelled on the inside, and is fitted into the spigot end of a trap pipe connecting with the branch

drain, or with a lead trap pipe which connects with the soil pipe. Immediately below the basin of the closet and at the top of the valve box, the valve is fitted which is operated by a "pull" handle fixed at the side of the convenience and usually in the woodwork of the seat. By means of this valve, water is retained in the basin of the apparatus to a depth of about one-third to one-half. On applying the pull the valve is drawn back, allowing the water and contents to be discharged through the valve box into the trapped pipe beneath.

Around the top of the basin is a flushing rim through which the water from the flushing apparatus passes ; at the back of the basin is a properly trapped overflow which connects at the top of the valve box. It might also be noted that a ventilation pipe is taken from the opposite side of the valve box. So much then for the construction of the valve closet. It may be said to be a fairly reliable type of closet, but it does not give some of the points we aim at with regard to these conveniences.

In the first place the metal valve box is in time found to become objectionable, in the second the valve itself may give a good deal of trouble, while objectionable odours proceed from many of these closets when the valve has been depressed, after they have been in use for a time. Again, this fitting requires to be "boxed" in, i.e. the whole apparatus has to be surrounded with wood fittings and seat, and as we are nowadays all out for sanitary conveniences being left as bare as possible, this latter point might be said to be an objection.

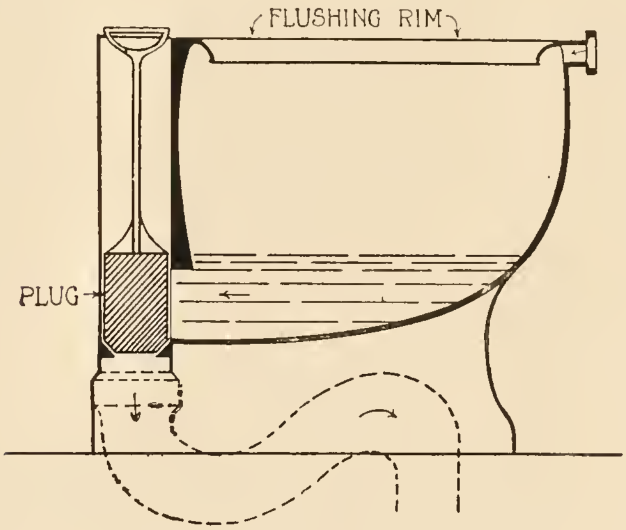


Fig. 99

Next we have the **Plug Closet** as shown in Fig. 99. Here again we have an enamelled earthenware basin fitted around the interior of the top with a flushing rim. Contained in a chamber at the side of the apparatus is a plug, operated by a handle on the seat. This plug is the water seal in connection with the appliance. The closet itself is not provided with a trap, so that in this case, as in the valve closet, a trap must be introduced immediately below the convenience. An overflow properly trapped is connected from the basin to the pipe beneath the plug. It will be seen at a glance that if the fitting of the valve be the least bit faulty then the water will escape, and a nuisance

will occur from want of water in the basin as also from any smells from the interior of the pipe. Indeed, even though the fitting of the plug and its seating be correct, there is always a liability to these nuisances through pieces of paper sticking between the plug and its seating.

This closet also is usually surrounded by woodwork and this very often screens much dirt and allows of a rough finish.

In Fig. 100 we have an illustration of the **Pan Closet,** which is never a satisfactory apparatus and ought to be condemned when met with.

Here we have an enamelled fireclay basin with flushing rim at top set in a metal container in which the pan works. This pan is made to fit the bottom opening of the basin and is operated by a lever from the seat. The closet itself is not trapped, and as in the case of the two foregoing types it requires to be fitted to a trapped pipe. One invariably finds that this form of closet is fitted to the objectionable D trap.

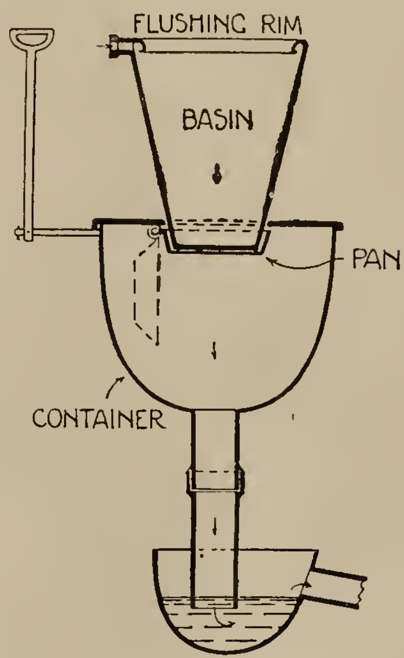


Fig. 100

A glance at the sketch will show just how objectionable this type of convenience is. The water in the basin is retained by means of the pan, and as this is liable to be "badly fitting," leaking, or encrusted, one often finds that the basin is empty of water.

When the lever is pulled up the pan is depressed and the water and excrementa are precipitated into the container underneath causing splashing and consequent soiling of the pan, container, and the bottom of the basin.

In a very short time the container becomes a collection of filth, giving off a stench which is most objectionable. One only requires to see one of these closets when taken apart after being even a short time in use to realise how dangerous and injurious they are. The whole convenience is boarded around to give it a finish, but there is very little that can be said of good in connection with the pan closet.

These three types of closets are very intricate and rather expensive, if put in properly, and in the case of the first two, viz. the valve and the plug, they may be fitted with care in such a way as to give a measure of satisfaction.

Let us now look at some types which are more simple in their construction.

The **Long Hopper** closet, as shown in Fig. 101, is what is known as the spiral flush type. Earlier types had different methods of flushing, but in this case the construction of the flushing rim imparts a spiral direction to the inflowing water, the idea of course being to clean the sides of the basin in the process of flushing. This pattern of closet consists of a conical-shaped basin in glazed stoneware, set on top of a syphon trap or S trap into which the excreta falls direct. As will be seen there is too much exposed surface in connection with the basin, and in a short time the closet instead of being a convenience becomes a nuisance.

Next we have the **Short Hopper**, which is a modification of the previous one. Here we have a different shaped basin as in

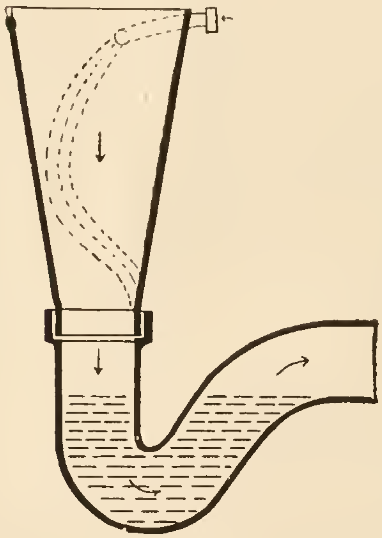


Fig. 101

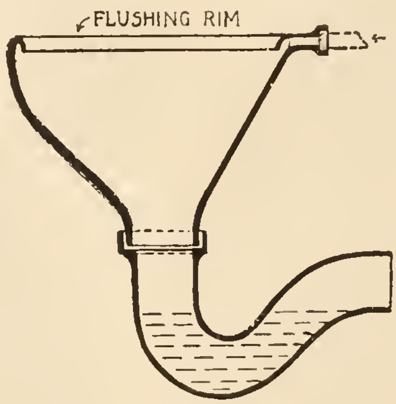


Fig. 102

Fig. 102, made also in glazed stoneware and set on top of an S or syphon trap as in the former case. A flushing rim is fitted at the top of the basin, but here again the liability of the basin becoming filthy, together with the arrangement of the trap and the want of antisyphonage arrangements, makes this type of closet hardly desirable.

The **Trapless Closet** as seen in Fig. 103 is fortunately one which is rarely met with nowadays. No attempt is made to provide a water seal for the closet. A valve operated by a handle from the seat retains the water in the basin and by pulling on this handle the valve is opened and the water passes into the drain. As will readily be understood, this type of closet is objectionable in many ways and should always be condemned when met with.

The next type of closet with which we will deal is that shown in Fig. 104 and known as the **Wash Out**, and is a pattern which

enjoyed for a time a good deal of popularity, if such a term can be used in connection with the subject, and consequently one comes across quite a lot of this kind of water-closet in everyday use.

In this case, the basin and trap are usually constructed of one piece of enamelled stoneware.

The basin is so shaped that it forms a shallow container for water into which the excremental matter falls, and the water and what it contains is carried by the flushing water over the back of this container to the trap underneath. Now it is in this connection that the weakness of this apparatus lies.

The downward rush of the flushing water is partly checked and arrested by this retainer, and besides losing a good deal of the value of the flush, splashing is likely to take place, with its consequent fouling of the sides of the basin by excremental particles; and again this arresting of the flushing water in its progress results in the trap being only partially emptied, while the pipe between the basin and the trap will soon become filthy through splashings from the trap, and as this pipe is not very easily got at for cleaning purposes, offensive odours will arise after the water-closet has been in use for a time. This fouling of enamelled surfaces by excremental matter is liable in time to cause the glaze on the surface of the apparatus to crack.

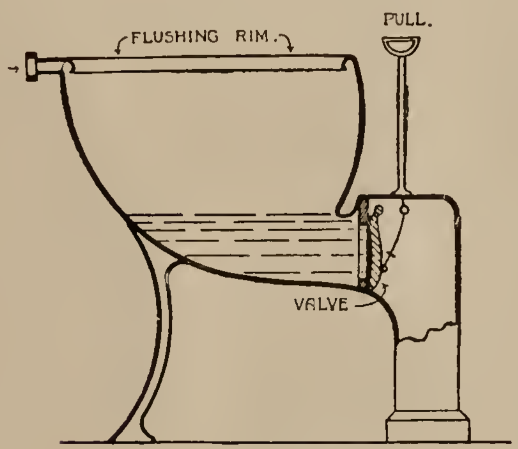


Fig. 103

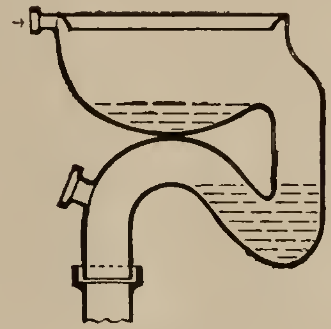


Fig. 104

We now come to the type of water-closet which is universally recognised as the model which corresponds with what is really wanted in connection with these conveniences. In Fig. 105 we have a typical pedestal wash-down water-closet. This convenience is made in one piece of white glazed earthenware. As will be seen, the upper part of the basin projects in such a manner that the closet may also be used as a slop sink or urinal. A flushing rim is fitted around the interior of the top of the basin. In some cases the horn, i.e. the pipe leading out from the trap, is cut short, while

in other cases it is extended and fitted with socket on top for anti-syphonage pipe. The flush is usually directed mostly from the front of the closet, so as to give a cascade action down the sloping part of the basin and thus ensure the thorough cleaning of the trap.

The whole closet is mounted on a good strong base and is finished with a glazed exterior. This type of closet is not boxed in, presents no interruption to the flush, is self cleansing, and simple in design.

A later pattern of this type of closet, brought out by Jennings of Lambeth, presents one or two interesting features as shown in Fig. 106. The principal feature in connection with this closet is that the upright arm at the back of the convenience (and which

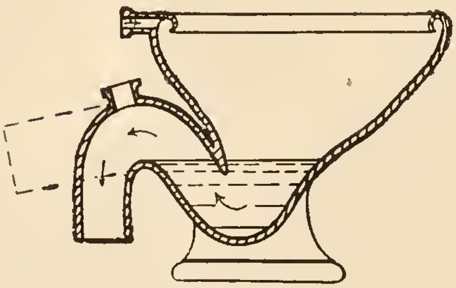


Fig. 105

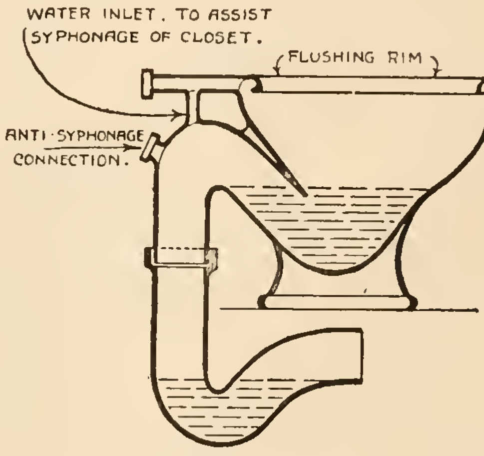


Fig. 106

connects with the syphon trap underneath) is carried upwards to a height sufficient to give a greater depth of water in the basin ; this gives a greater water area and also a deeper water seal. The next important feature in this apparatus is the double trap arrangement on the descending arm before it joins the soil pipe.

Another important feature is that a connection with the flush pipe from the cistern to the flushing rim is made at the top of this upright arm, which assists considerably the syphonic action of the closet when in use. This type of water-closet is cleanly, and self-cleansing in its action. It may be a little more expensive to fit than some other types of wash-down water-closets, but it will amply repay such extra initial outlay when in use.

Before dealing with other types of water-closets, it may be as well here to consider the flushing appliances used in connection with the appliances just described. With the plug, the valve, and the pan closets, a special means of water flush is required, and this is accomplished by mechanism of the *supply valve and bellows regulator* type or a modification of the same. The apparatus

is so arranged that it works in conjunction with the "pull" or lever of the closet. In some cases, the flushing apparatus is constructed along with the mechanism of the closet, and in other cases it is supplied separately. Let us take the apparatus by itself so that we may better understand it. In Fig. 107, we have shown the apparatus by itself which consists of a small cylinder with bellows and stop cock (1), and weighted arm (2) and the shut off valve on the service pipe at (3).

By means of the small stop cock or tap on the side of the cylinder, the time taken for the bellows to resume its original position after contraction is regulated, and this of course regulates the length of time taken to flush the apparatus. On using the pull,

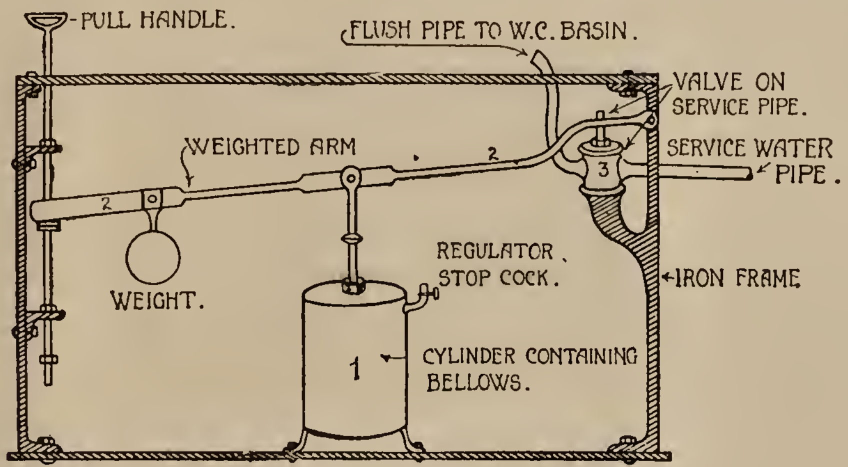


Fig. 107

the weighted arm is raised, which in turn pulls up the connecting rod of the bellows, thereby compressing them and at the same time opening the valve at (3) on the service pipe. The weighted arm then comes into operation and, air passing into the bellows *via* the stop cock, this arm gradually descends until it closes the service valve at (3). It is claimed that by this method a great saving of water is effected, and while that is conceded in this case, the saving is made at the expense, too often, of cleanliness. Other methods and types of these regulators are on similar lines to the one explained, and, as already stated, they are essential with the first three types of closets described.

With other types of water-closets, cisterns or *water waste preventers* are used. These should always be of a size sufficient to give a minimum two-gallon flush, and wherever possible a three-gallon flush should be employed. These cisterns are usually made of galvanised iron, and may either be fitted as finished, or cased in with polished woodwork to give a good decorative effect. In some cases, the cistern is boxed in, in order to render the action of it in filling and emptying as noiseless as possible, but we now

have cisterns on the market which are claimed to be noiseless in their action.

We will take two of these waste preventers and deal with their construction and action.

First, then, we have the **Plug** or **Spindle Valve** flushing cistern as shown in Fig. 108. With this pattern of cistern there is very little mechanism; the apparatus consists of a tank, fitted inside of which is a spindle or "top shaped" valve which is made to fit a seating at the top of the flushing pipe. To the top of this valve is a pin or chain which is connected to a lever working over the side of the cistern. At the other end of this lever is the chain and handle. On the handle being pulled the valve is lifted from

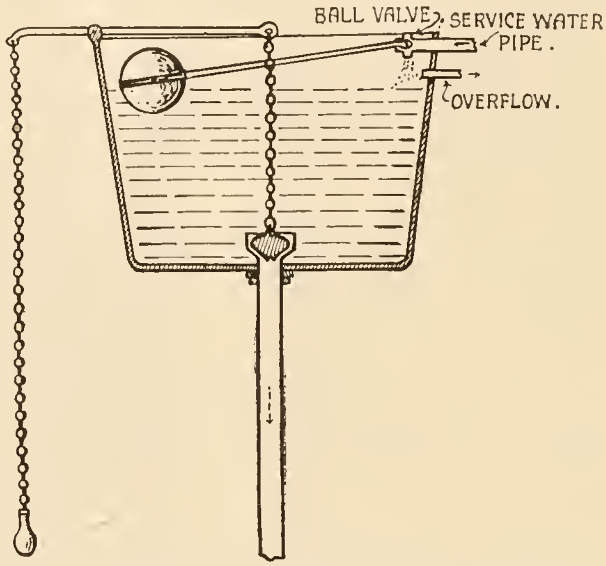


Fig. 108

its seating and the water passes down the pipe to the basin of the closet and flushes it. The water continues to pass until the handle is released, when the valve returns to its seating and prevents any more water passing. The supply of water in the cistern itself is regulated by a ball valve attached to the feed pipe of the cistern, and which consists of a light copper ball soldered to the end of a metal arm; the other end of this arm is hinged to a valve. The copper ball floats in the water and as the water rises in the cistern the ball ascends and, raising the metal arm, closes the valve on the service pipe. But to go back to the principal part of the cistern we find it has many disadvantages. To ensure a good flush the valve requires to be held up for a considerable time, and this is not always done. Again, the valve very easily becomes leaky and "badly fitted," and then there is a big waste of water.

The second pattern of water waste preventers we will consider is that shown in Fig. 109, and this is the most common type of

water-closet cistern in use at present and known as the **Ordinary Syphon Cistern.** In this case, the flush pipe may be said to be continued up into the cistern in the form of a syphon finishing within a short distance of the bottom of the cistern. On the side of the ascending pipe, we have a short branch pipe set in at right angles which has a valve seating at its exterior, and fitted to this seating we have a metal valve and rubber washer.

This valve is operated by a lever working over the edge of the cistern and connected to the valve by means of a chain or wire link; the outer end of the lever is fitted with chain and pull or handle. The cistern is fitted with floating ball valve as described in connection with spindle-valve cistern, while an overflow pipe is

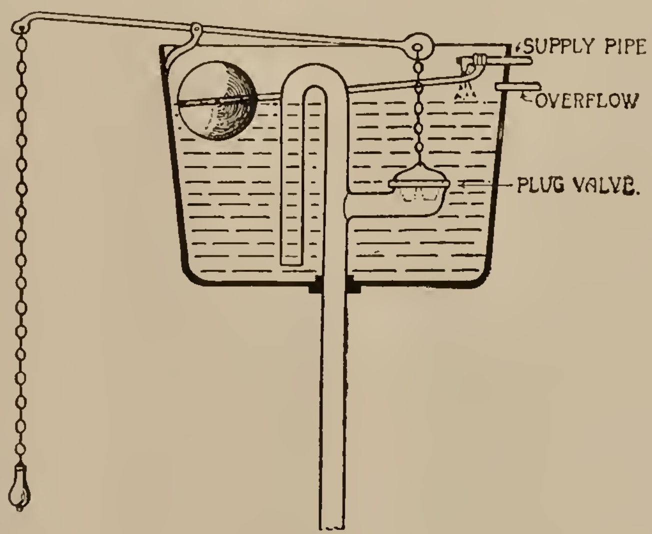


Fig. 109

carried from the side of the cistern above the water level when normally full.

On the handle being pulled, the valve is lifted and the water rushing in causes a partial vacuum in the flush pipe, and the atmospheric pressure acting on the surface of the water causes it to rise up the small syphon pipe, and syphonage being started, it continues until the cistern is emptied. This cistern has a good deal to commend it and gives much satisfaction.

The greatest trouble with galvanised cisterns is due to rust which may in time gather inside the cistern and, being carried down by the flushing water, stain the basin. For this reason, many people prefer to have the casing of the cistern made of some hard wood and covered inside with lead.

Another objection to these common cisterns is the noise which they make in filling and emptying, and many "silent" cisterns are now on the market to overcome this difficulty. The construction of these is practically the same as in the syphon

cistern, the noise of the incoming water being deadened by the arrangement of a pipe carried from the ball valve down to the bottom of the tank, while to deaden the noise of the emptying process, one method is to have a special valve fitted at or near the top of the syphon itself.

These flushing tanks are fitted as a rule as high above the convenience as practical, and in such a way that no bends will require to be introduced in the flushing pipe.

The flush pipe which connects the water-closet and cistern should be $1\frac{1}{4}$ inches in diameter if more than 4 feet above the closet, if less than 4 feet then the pipe should be of larger diameter, say $1\frac{1}{2}$ inches.

These pipes are usually made of drawn lead, but copper and brass is often used for the purpose, especially where ornamentation is aimed at. In some cases, galvanised iron pipes are used with a fair measure of satisfaction.

The seats of water-closets are made of polished hard-woods hinged to a back piece, the back piece being secured by screws to the back of the closet.

In water-closets introduced into poorer-class dwellings, seats are not provided ; instead, two checks are left in the stoneware of the top of the basin, one on either side, and pieces of smooth hard-wood are fitted in to remove the discomfort of sitting down on the cold earthenware.

In connection with all water-closets, it is very essential that they should be fitted with what is known as a *safe*. This safe is made of lead, the sides being formed by turning up the edges of the lead to a depth of $3\frac{1}{2}$ to 4 inches, the angles being soldered.

This safe is fitted on the floor and under the water-closet itself. From the safe a pipe is carried off from $1\frac{1}{2}$ to 2 inches diameter, the purpose of this pipe being to carry off any water which may gather in the safe from chokage, etc. Errors in dealing with this "safe-pipe" are very common. Evidently the plumber is at a loss sometimes where to carry it, and it is no unusual thing to find it connected to the soil pipe or into a trap below the closet itself. The proper method is to carry this pipe direct through the wall of the building, where it should be cut short in the open air and a hinged flap fixed obliquely on the end of it to prevent wind blowing in through the pipe or birds nesting in it.

We will leave the assembling of the water-closet till later and now pass on to a study of other kinds of water-closet conveniences which differ from those already discussed.

In districts where the water supply is very short and special measures regarding its use have to be adopted, another type of water-closet is met with known as the **Slop Water-closet.** In

this case, all waste water from sinks and surface traps is made use of for flushing purposes. There are various types of this kind of closet but they all resemble each other a good deal, so we will

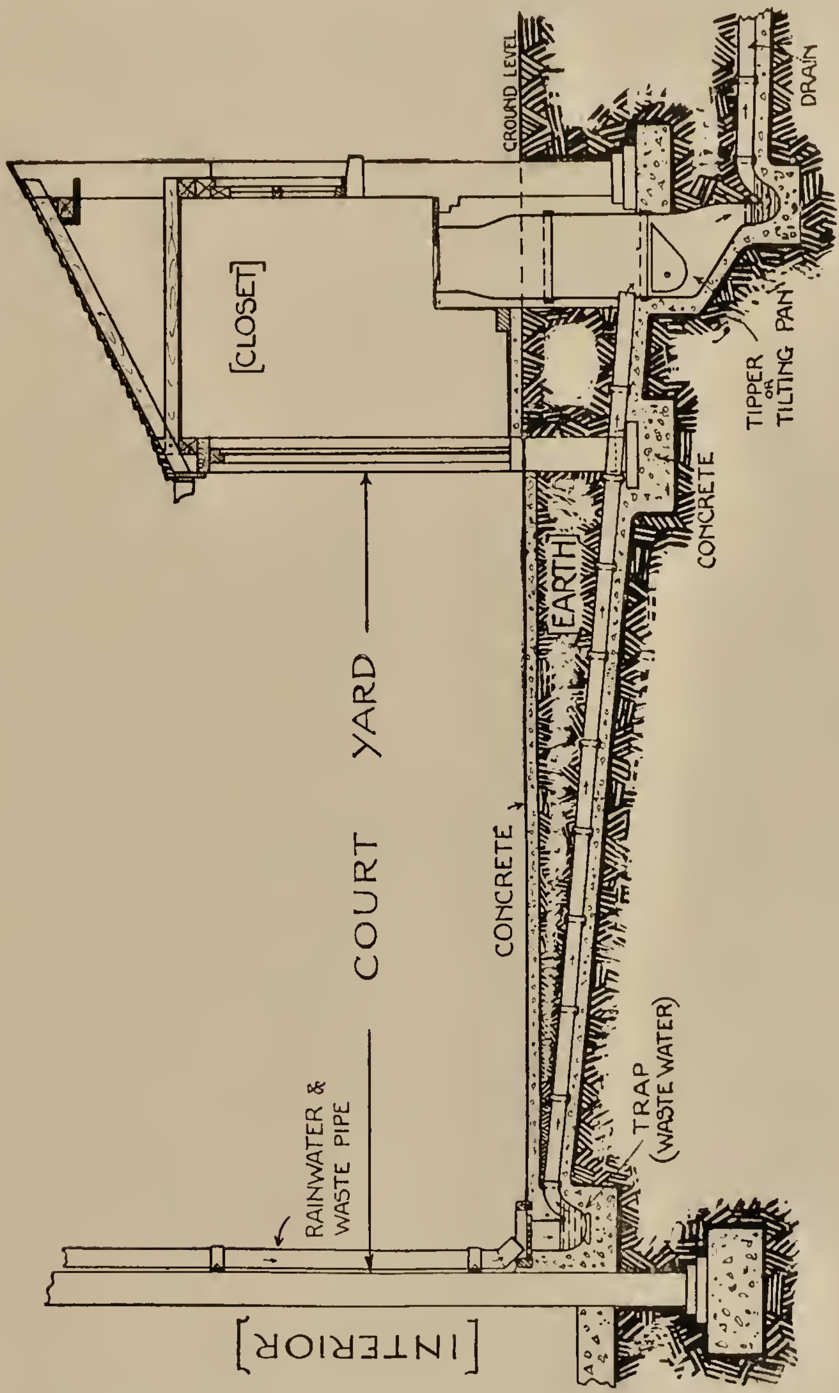


Fig. 110

take one found in common use for the purpose of studying its construction and action.

In Fig. 110, we have what is known as **Day's Slop Water-closet.** The closet itself is usually bottle-shaped, being smaller at the top where the seat is than at the bottom. Immediately

beneath this hopper is fitted a tipper or basin which works on pivots fixed on either side to busches in the walls of the under chamber. Under this tipper is a syphon trap connected to the drain. Directly over the tipper is a pipe leading in from the drain and conveying waste sink water and surface drainage. When the closet is in use, the excremental matter falls into the tipper, and the water from the drain above washes it and any water in the tipper into the trap and drain immediately below. The tipper is so balanced that on its being filled with water it tips up and discharges its contents. In other closets of this type, the tipper or tilting pan is situated beneath a trap at the top of the drain. In this case, the tipper is

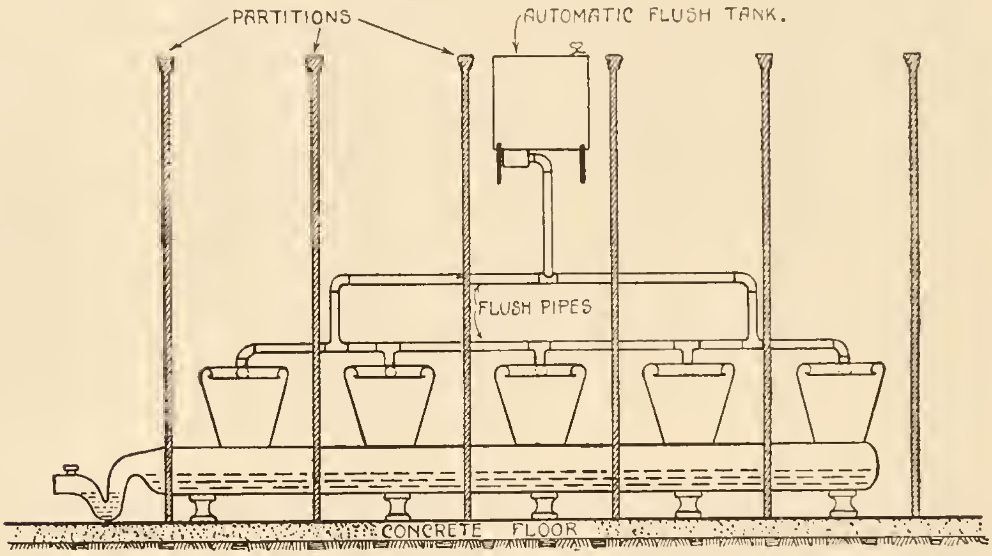


Fig. 111

made to hold about 3 gallons of water, and when full this volume is tipped up and discharged down the drain over which the closet is, at some point, built. While this type of closet may leave much to be desired from the sanitarian's point of view, still it is much to be preferred to the privy midden.

Next we have what are known are **Trough Closets** used in connection with schools, halls, public conveniences, workshops, and manufactories.

These consist of a range of water-closets of any number as shown in Fig. 111. They may be had either in enamelled iron or in earthenware or glazed stoneware. They consist of a series of basins of hopper shape set over a channel which has a weir fitted at the lower end, which ensures a certain amount of water always being in the channel into which the fæces drop. At the top end of the range of closets we have an automatic flushing cistern which regularly flushes the whole channel, carrying with it all excremental matters.

Between each closet, a partition is of course erected for quite obvious reasons. In the older type of trough closets the hopper basin is not found and beneath the seat there is no division whatever between the closets. Also the flushing pipe in the old type was connected to the channel under the closets, but in latter types the basins are fitted with flushing rims and a connection to each pan from the flush pipe is made, so that a more cleanly state of affairs is accomplished. At the outlet end of the closet, the apparatus is trapped before entering the drain. These closets, when properly looked after, and where there is an ample supply of water, give much satisfaction.

Urinals.—These conveniences are of course provided in connection with large buildings, public halls, schools, railway centres and stations, etc. Various types are in use including those used as public conveniences, such as we find in the streets in some towns. These are made of cast iron, freely ventilated, and with cast iron stalls, which are flushed as often as possible by means of an automatic flushing tank. The more modern type of urinal consists of glazed earthenware stalls which finish at the bottom in a glazed channel; an automatic flush tank is connected to the flushing rim at the top of the stall by means of a flush pipe.

It is essential that the floors and walls of urinals must be of an impervious material such as cement concrete, finished, if desired, in granolithic work.

It is equally important that the flush must wash the whole of the exposed surface of the stall itself. Indeed, if one wishes to avoid nuisances from this kind of convenience, then an abundant water flush must be provided. Now, the urine and flush water is carried along the channel to a trap into which it discharges before passing to the drain.

Twyfords of Hanley are the makers of a very satisfactory type of urinal as shown in Fig. 112. This convenience is simple, self cleansing, and gives every satisfaction.

In other types, a treadle arrangement is introduced at the foot of the stall so that any one using the convenience by standing on the treadle causes a flush of water to pass out into the channel and so dilute the urine. Another type of urinal has, instead of the channel at bottom, a basin fixed at a convenient height and flushed regularly with plenty of water. Stall urinals are made of many materials including cast iron, granite slabs, slate slabs, glazed earthenware, marble, etc. Of these, the last two are really the best. A plentiful supply of flushing water, covering the whole of the exposed surface of the stall, as already said, is the best adjunct of a urinal.

In all large institutions, especially hospitals, we come across another convenience closely resembling a wash-down water-closet :

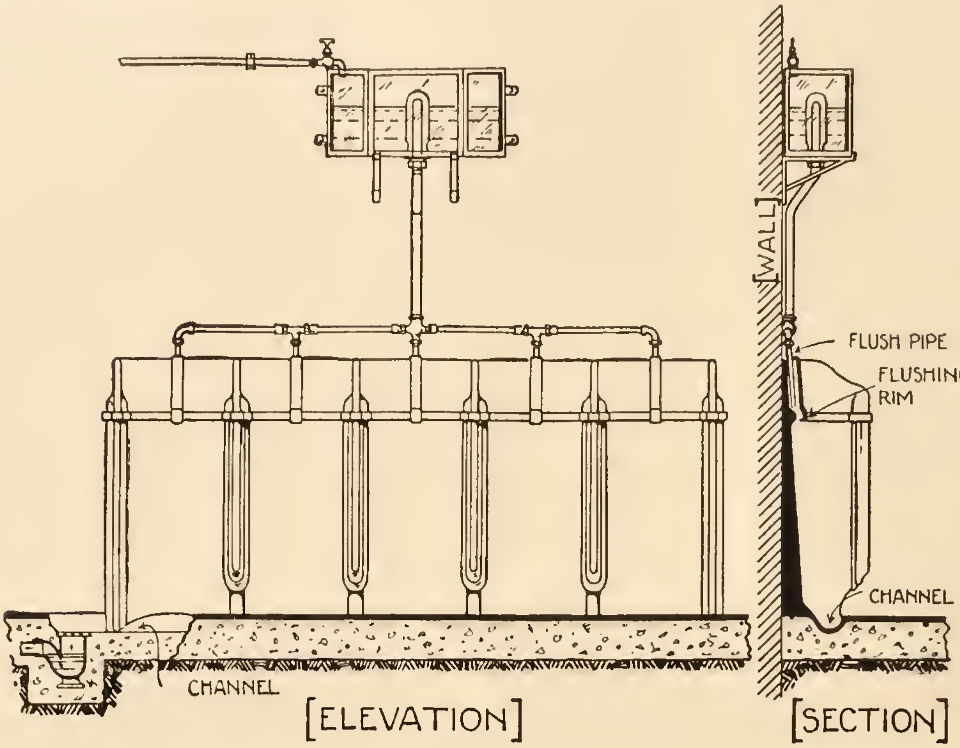


Fig. 112

this is known as a **Slop Sink,** and is shown in Fig. 113. This apparatus is made in one piece of glazed earthenware on the same principle as the wash-down water-closet, only that it is finished with what is known as a "table top" or broad rim and a metal grid is fixed half way up the basin for the purpose of resting pails on. Another difference is that the outlet pipe need only be 2 to $2\frac{1}{2}$ inches in diameter. A cistern, or water waste preventer, is connected by means of a flush pipe to a flushing rim at the top of the basin.

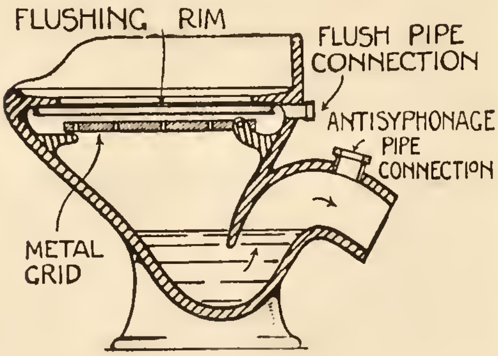


Fig. 113

In an ordinary house, the water-closet—with ordinary care—serves the purpose of a slop sink.

Slop sinks are trapped the same as closets, special attention being paid to an antisyphonage pipe on top of trap.

Chapter XIV

WASHHAND BASINS, SINKS, BATHS, ETC.

HAVING considered the various types of water-closets, etc., let us look now at some of the other sanitary fittings to be met with in buildings. First, then, we have **washhand basins** as fitted in lavatories. In the old method of fixing, these were without exception cased in with woodwork, and inside these casings one usually found a good deal of dust and rubbish. Nowadays, we insist on all sanitary fittings being open so that not only is the fitting itself exposed but so also are the waste pipes, joints, and traps. Washhand basins are made in enamelled cast iron and glazed earthenware, the latter being the best. As will be seen in Fig. 114 these are very simple in construction, consisting of a basin fitted at the bottom with a metal (usually brass) connection made to take a rubber plug, while on the back are fitted either one or two connections for water taps. In the case of two taps, one is for hot water of course. In some of the more expensive types, a knob arrangement is provided between the taps which controls a valve to prevent the escape of water from the basin when in use, which is an improvement on the rubber plug used in simpler forms of the appliance for the same purpose. At the back of the basin and towards the top of it are a number of small holes which are the inlets to the overflow pipe provided as a precaution against flooding. This overflow pipe is made in the same casting as the basin itself and is carried down the back of the fitting and joins the waste pipe.

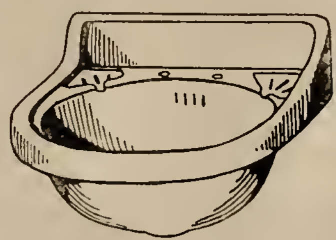


Fig 114.

The washhand basin is trapped underneath by a drawn lead pipe trap of about 2 inches diameter, and made either in P, Q, or S pattern as the case may be, so as best to adapt it to the waste pipe fittings.

This trap must be provided with an antisyphonage pipe carried from the top at a point beyond the water seal.

These washbasins are usually fixed on a bracket iron frame

fixed to the wall of the room. They may be had in various shapes, square, oblong, circular, or in triangular shape where for the sake of saving space they are fitted in a corner.

The next fittings we come to consider are **baths.** Here again the rule used to be to have these cased in with woodwork, but happily we have now got away from that state of affairs. Baths are made in many different designs some of which, fitted with glass screens at the top and sprayers and shower taps, are very nice and ornamental. Baths are made in marble occasionally but more often in cast iron enamelled, or glazed earthenware. It will suffice for our purpose if we take the most popular type of bath which is very simple in construction. This bath, as shown in Fig. 115, is mounted usually on four claw feet so as to give a space between the bottom of the bath and the floor ; at the broad end,

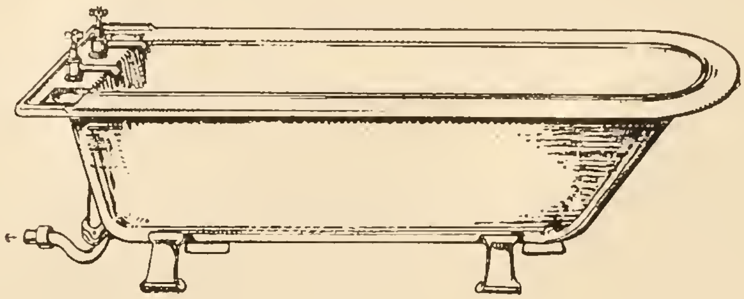


Fig. 115

a ledge is provided to take the taps and waste lever. In the bottom of the bath an opening provided with a grating and connected to a coupling for the trap is made, and with this arrangement we have a valve which is operated by the waste water lever, in order to run off the waste water from the bath or prevent water from passing through according to the requirements of the moment. An overflow is provided near the top of the bath at the square end and below the flange to prevent the bath overflowing and causing flooding. The bath itself is properly trapped immediately beneath the square end by means of a modified form of an anti-D trap, or by means of a lead trap in P, Q, or S shape. If the latter type of trap is used, then an antisyphonage pipe must be provided, while in the case of anti-D traps, it is not usual to fit such a pipe with baths.

Next in order of sanitary fittings we have **sinks.** These may be made of various materials as, for example, glazed earthenware, iron, and in some cases hard-wood lined with lead or tinned copper. With the latter type, it is held that there is less damage to glass or china, but that hardly justifies their use for the purpose. Where these types of sinks are used, it is important to see that

the metal is of sufficient thickness to prevent wearing thin rapidly or being easily punctured. Glazed earthenware sinks are best, and may be had in the varying sizes required for all manner of purposes. They are fitted with overflow pipe and connection for trap and waste pipe, a metal or rubber plug being provided which is made to fit the outlet from the sink. With most sinks, no provision is made for the taps as these are usually fitted over the sink by wall connections. Some are inclined to think that as the sink waste pipe discharges over a gully trap outside the building, there is no reason for the sink being trapped inside, but it is very important that this should be done and a drawn lead P, Q, or S trap connected immediately below the sink and fitted with a "puff" pipe (or antisyphonage pipe) from the top of the trap beyond the water seal. In the case of antisyphonage or "puff" pipes with sinks, these are usually carried through the external wall of the building and cut short, being fitted with a hinged flap to exclude winds, etc.

We now come to the question of **tubs** used for washing and laundry purposes. In many cases, these are made of wood of sufficient strength and thickness and jointed with white lead. The water is laid on as in the case of sinks by wall fixings, and provision is made at the bottom of the tubs for the escape of water by a cup-shaped opening made to take a metal plug attached to a chain, this opening communicating with a trap underneath. In the more up-to-date type of tubs, we have them made of glazed earthenware, and these are much cleaner and durable and give a great deal more satisfaction. In cases where wooden tubs are used, one very often has repeated complaints of smells, and there is little wonder at this being the case owing to the woodwork in time becoming rotten. Tubs require to be trapped by a drawn lead pipe trap of P, Q, or S shape according as required, and a puff pipe or antisyphonage pipe provided as in the case of sinks. It often happens, however, that there is a range of tubs, and the waste pipe is carried straight down to a channel running under the tubs and discharging into a gully trap in the floor made to take the surface water.

This practice is not to be commended, however, as even surface water ought to be led by means of a channel or pipe through the wall and discharge over a gully trap outside.

Both tubs and sinks of glazed earthenware are usually erected on piers or pedestals of the same materials as the fittings themselves, and in this way we have easy access to the pipes, traps, connections, etc.

Chapter XV

DETAILS OF FIXING SANITARY APPLIANCES

HAVING considered the various sanitary appliances in use and their construction, we now come to the important study of how they ought to be assembled and fitted in the building itself, but before doing so it is very necessary for the student who has not had some experience as a plumber that he should have a little knowledge at least of some of the principal tools, etc., used in connection with the work, so we will briefly consider one or two of these articles now as well as the more common types of joints one meets with in "plumber work."

The commonest tool one meets with in a plumber's kit is his **"grips,"** an adjustable type of pliers by which he can screw or unscrew nuts, etc., of varying sizes.

Next we have a **soldering bolt** made of copper riveted to an iron shaft and fitted with a detachable handle.

Fig. 116

Fig. 116 shows what is known as a **"dresser"** made of wood and used for all kinds of lead working.

Mandrils are circular pieces of wood of diameters equalling the corresponding interior diameters of pipes. They are used to straighten or take dents out of pipes damaged in transit.

These mandrils are usually about 2 feet long and are driven down the interior of the pipe while another operator by means of a dresser removes any surface irregularities.

In making bends in lead pipes, there is always a tendency for the pipe to become flat at the heel, i.e. the part outside where the bend is made. This flat part is removed by means of the dresser used with the aid of a **dummy**. The dummy is an elliptical-shaped block of lead, slightly flattened and riveted to an iron shaft which is fitted with a wooden handle. The method of procedure is that, while an assistant hammers the inside of the flattened part of the bend with the dummy, the plumber by means of the dresser hammers the outside of the pipe into its circular shape.

Bobbins are used when making bends in pipes which are too small in diameter to admit of the use of the dummy. These

bobbins are made of hard-wood, flattened at either end, and are made in series, that is they begin with one considerably smaller than the diameter of the pipe and are graded until the necessary size is reached, and then get smaller again until the last one is reached which is of the same diameter as the first. In practice, the bobbins are introduced into the pipe, commencing with the small one, and then the others are introduced in succession according to size and driven through the pipe to restore the circular shape.

In connection with caulked lead joints **caulking irons** are used, and these consist of blunt steel chisels, so made that the part forming the handle is rounded, the blade being flat, or slightly rounded, and the handle set on a slightly higher plane than the blade.

Hack saws are usually about a foot long and are made of specially hardened steel; they fit into skeleton iron or metal frames similar to fret-saw frames, and are used for cutting pipes and metal.

Snips are used for cutting wire, zinc, etc., and are made in various sizes similar to shears which consist of a double blade fixed to a spring handle.

These, together with mallets and hammers, screw-drivers, etc., are the tools most commonly used, while **hand blow-lamps** form a very important part of the modern plumber's equipment. These lamps, which are small and compact, burn oil under compression and give a very great heat indeed.

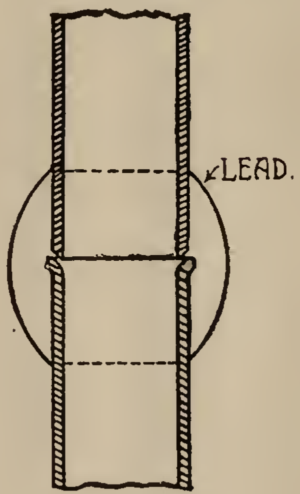


Fig. 117

Dealing now with the various types of joints used in pipes, we have already seen how a caulked iron pipe joint is made with heavy pipes; we will therefore discuss joints made with lead pipes, the principal one of which is known as a wiped joint.

To make a **wiped joint** as shown in Fig. 117, it is necessary to see that the ends of the two pipes to be joined are cut squarely across. We now take the end of one length of pipe and with a tan pin, which is a cone-shaped block of box-wood, and a wooden mallet, we are able to hammer the end of the pipe into such a shape as to make it bulge around the edge so that it can easily receive the end of the other pipe to be joined.

We now treat this other end in a similar fashion to the first, but in a lesser degree, so that less bulging is produced. Having done this, we then fit the two ends together and "rasp" them

down so that only a thin edge is left on the end of the entering pipe. The rasp employed for this work is a coarse file specially made for the purpose. Having now adjusted the ends and secured them by means of an adjustable cramp, we now apply a coating of smudge all round the pipes and for a distance of from 3 to 4 inches along the pipes from the joint. This smudge may be bought ready for use or made with lamp black, glue, and whiting.

When the smudge has dried, the pipe, or that part of it which has been painted, is then shaved with a shavehook (a knife with a hooked blade, or in some cases a triangular-shaped knife fitted on a handle); great care should be taken not to take away too much of the lead, as it actually only requires the removal of the paint and a fine shaving of the lead itself. One might reasonably be excused for asking why the plumber puts on the paint only to scrape it off again, but the reason is that a great deal of the success of making this joint depends upon having a perfectly untarnished surface for the making of the joint and this can best be attained by applying the smudge which—by reason of its blackness—prevents any part from being omitted in the scraping process.

Having now shaved the pipes clean, we cover the shaven parts with grease, usually tallow, to prevent the new surface becoming retarnished. The plumber now takes what is known as a "soldering cloth," which is made of moleskin, corduroy, or some similar material of three of four thicknesses, and smears it over with grease so that the solder will not adhere to it. The solder is now poured on by means of a ladle over the joint and wiped into shape with the soldering cloth.

Where the pipes are of large diameter, there is always a risk, especially in cold weather, of the solder going cold in the process of wiping, and soldering irons were therefore formerly used to heat the solder. Now we have the hand blow-lamp, which is much more suitable and gives a better finish under these circumstances.

Care must be taken in heating the solder for this work so that it is not overheated, as in that case it does not "wipe" so well. The practice of many good plumbers, to find out if the solder is ready, is simply to put a piece of paper into the molten metal, and if the paper ignites, the pot with the solder is taken off the fire.

The next joint in common use is what is known as the **copper-bit joint** and is the joy of the plumber whose skill does not extend to the art of the wiped joint.

With the copper-bit joint, the ends of the pipes are prepared in a similar manner to those for a wiped joint; only in the case of the pipe with the projecting edge, this projection must be carried even farther out. The pipes having been adjusted in position,

the plumber (using a soldering iron and a stick of solder) proceeds to run solder around the joint until he has made it secure.

This kind of joint may do well enough for pipes of very small diameter, but in all good work the wiped joint must be insisted upon.

The **blown joint** is a modification of the copper bit, the difference being that in place of a soldering iron for running the solder a blowpipe flame is used. This type of joint is only found in the poorest classes of plumbing work.

The various pipes used in connection with sanitary fittings must now be considered, as also the names which are given to them. The pipes used are heavy and light cast-iron pipes, drawn lead pipes, seamed lead pipes, and zinc pipes. The latter, however, are now only met with in old work as a rule.

Heavy cast-iron pipes coated with Dr. Angus Smith's varnish make very good soil pipes and allow of a good caulked lead joint being made. These pipes are the same as those used for small water mains.

Light cast-iron pipes are used for rainwater conductors and, in some cases, sink and lavatory wastes, but as they do not allow of a good strong joint being made, and as they are not as a rule protected against corrosion, they are not very satisfactory, while in addition they are liable to be fractured or cracked when the frosts of winter come along.

Medium heavy cast-iron pipes are used for rain-water, sink waste water, lavatory and bath wastes, and, in addition, they are supplied in small diameters as antisyphonage pipes.

Drawn lead pipes are good when used for soil pipes, as reliable joints can be made and a union with the trap of the fitting is easily accomplished. Being smooth in the interior, they present no barrier to the free flow of waste while they do not corrode very readily.

These pipes must not be confused with **seamed lead pipes** sometimes used for the same purpose.

Seamed lead pipes are very unsatisfactory, and are really inadmissible for this kind of work, owing to the fact that they so easily become faulty. This kind of pipe is made by rolling a piece of sheet lead, of required length, on a roller, and soldering the edges together, thus giving a seam the whole length of the pipe. This seam in time becomes faulty owing to corrosion having weakened the joint or union, and variations in temperature which cause contraction and expansion in the metal soon play havoc with the joint.

Rhones or **gutters,** made to receive the rainfall from the roof, are made of iron, lead, zinc, or tin, and may be of various shapes, some of which are shown in Fig. 118.

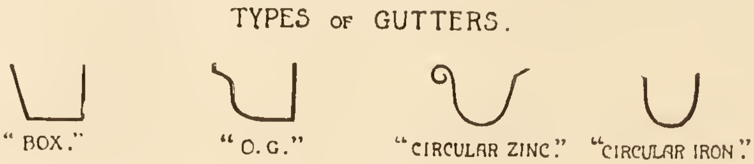


Fig. 118

Filler heads are also made of similar metals, and are used at the top of the rainwater conductor to receive the roof water. In some cases these are worked out in ornamental fashion. Fig. 119 gives a plain type of filler head.

It is very desirable that all pipes should be placed outside the wall of the building. Soil pipes, of course, must be kept out-

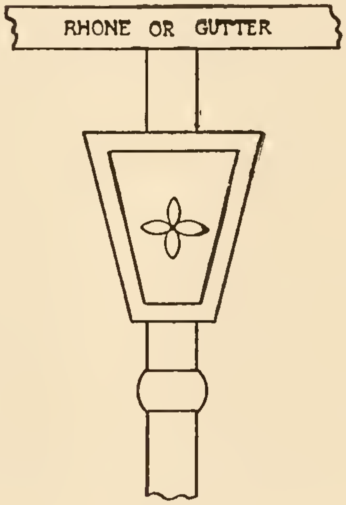


Fig. 119

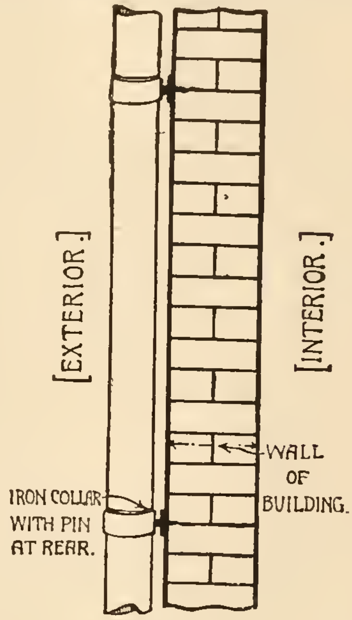


Fig. 120

side, and all other waste pipes should be treated the same. They ought not to be fixed in recesses left in the wall as is sometimes the case, nor fixed hard to the face of the wall, but should be fitted in such a manner that the brackets or holdfasts keep them clear of the face of the wall and allow a space between the two as shown in Fig. 120. This is a detail worth noting, as dampness in walls is often due to waste pipes either set in recesses in the walls or fixed hard to the face of the wall; moreover, the pipe may become partially choked, or leaky joints may occur; or perhaps a length of the pipe next to the wall may be fractured. Now, pipes when erected are known as soil pipes, rainwater pipes, and waste-water pipes.

The **Soil pipe** conveys all waste and excremental matters from water-closets and slop sinks. It is made of either heavy cast iron, protected with Smith's varnish, or of drawn lead. It should be carried up the wall to a point clear of all openings to the house, the end being fitted with a guard of wire mesh to prevent birds building nests in same, etc.

This carrying up of the pipe, as shown in Fig. 121, allows of proper ventilation not only to the soil pipe, but also in a measure to the drain itself. The joints of the soil pipe, if one of cast iron, must be made of caulked lead as already explained, and if of drawn lead, then wiped joints ought to be made.

N.B.—The soil pipe is not disconnected at the bottom by a trap, but joins the drain direct.

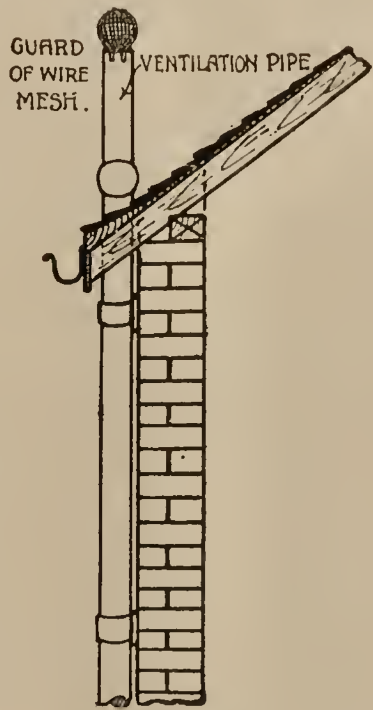


Fig. 121

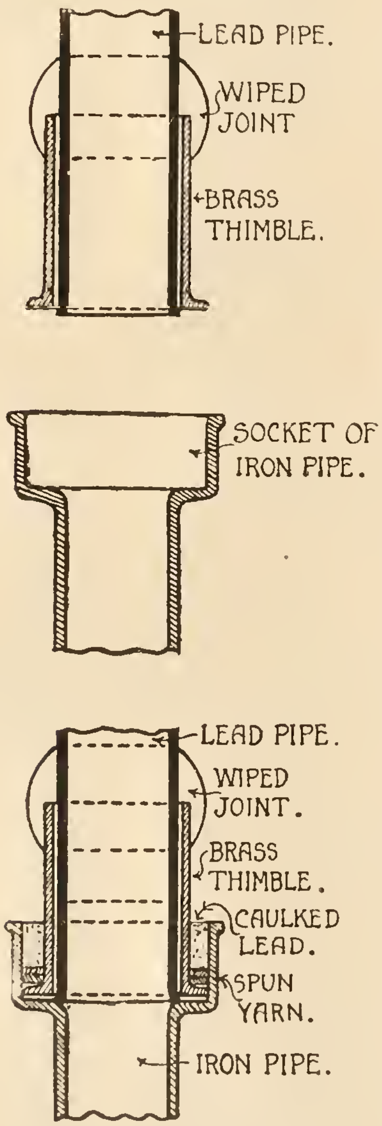
Waste pipes are used to take all waste waters from sinks, washhand basins, baths, etc., and should be made either of heavy or medium cast iron or drawn lead pipes, and the same kind of joints employed as in the case of soil pipes. In this case also, the pipe is carried to a point clear of all openings to the house, for ventilation purposes, and fitted with a guard of wire mesh.

Unlike the soil pipe, the waste pipe does not join the drain direct, but is made to discharge over the grating of a gully trap. It very often happens that waste pipes are only carried up to the top of the wall of the building, and there they receive the rain-water from the roof running in the rhones. This is a practice which should never be encouraged, as by doing so it often happens that at the time when ventilation of the waste pipe is most required the pipe is running fairly full of roof rainwater, and so the object aimed at is lost. Where the eaves of the house project beyond the wall of the building the continuation of the soil or waste pipe should be made by cutting a hole to allow the pipe to pass through. Very often one finds that the plumber uses an "offset" or bent pipe to carry the extension round the roof projection, but this, of course, presents a certain amount of obstruction to the free passage of air in the pipe.

Rainwater pipes are used to carry the roof rainwater from the gutters or rhones to the drain, being disconnected by means of a gully trap at the ground level over which the rainwater

conductor discharges. These pipes are often made of very light cast iron or zinc. The latter, however, is rather expensive for the purpose, and the former often gives a lot of trouble ; a medium cast-iron pipe is therefore the best to employ for the purpose. The conductor terminates short of the rhone or gutter and is fitted on its top end with a filler head into which a short pipe from the rhone passes. When light iron pipes are used, one usually finds the joints made of red lead, putty or cement, and one will readily understand that such joints do not give much satisfaction.

We have still another type of pipe to consider, namely, the **Antisyphonage pipe**. This is usually made of medium cast iron or drawn lead and is carried to a point above the highest water-closet or bath waste—according to which fitting it serves—and there joined to the ventilation part of the stack or pipe. The system of connecting this will be considered later.



SHOWING JOINT MADE

Fig. 122

Having disposed of the various kinds of stacks or pipes, we come now to the nature of connection between the fitting and the waste pipe or soil pipe. It may be pointed out here that it is neither practical nor desirable to join, say, an earthenware basin to a lead or iron pipe in any odd sort of fashion. For instance, cases have occurred where the tradesmen have tried to make such a connection by inserting the one into the other and "bandaging" the "joint" with canvas, covered with clay. To obviate such "scamp-work," certain types of *connections* are recommended, and in many districts enforced. These we will now consider.

Lead and Iron.—Where a connection has to be made between a lead soil pipe, or waste pipe, or trap, with an iron pipe or drain, the lead pipe or trap must have on its outgoing edge a flanged thimble of copper, brass, or other suitable alloy. This "thimble," as shown in Fig. 122, is secured to the lead pipe by a proper wiped joint.

When completed, this is inserted into the socket of the iron pipe or drain and a good joint made by caulking with lead.

Stoneware and Lead.—Where a connection has to be made between a stoneware trap or pipe and a lead soil pipe, waste pipe, or trap, such as in fixing water-closets, the lead pipe must be fitted with a socket of copper, brass, or other suitable alloy in the manner shown in Fig. 123, and secured to the lead pipe by means of a proper wiped joint. The stoneware trap or pipe is then entered in this socket, and a good joint made with Portland cement or other suitable material.

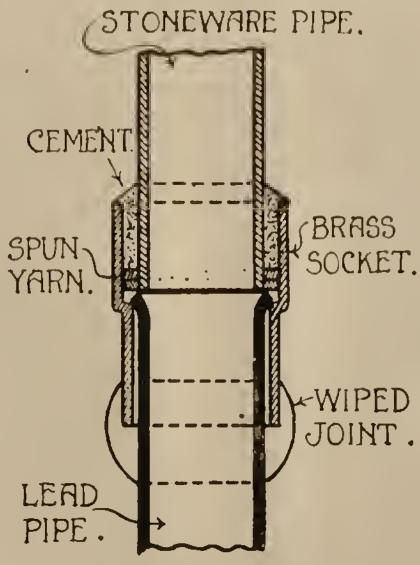


Fig. 123

If the connection to be made is between a lead soil pipe and the end of a stoneware drain, then the lead pipe must have fixed to its lower end, by a wiped joint, a flanged thimble of copper, brass, or other suitable alloy similar to that shown in Fig. 122. This flanged thimble is then inserted into the socket of the stoneware drain pipe and the joint made with cement.

Stoneware and Iron.—When it is necessary to make a connection between an iron pipe and a stoneware drain, the beaded end of the iron pipe has to be inserted into the socket of the stoneware drain pipe, and the joint made with cement. Should the connection be between a water-closet and an iron pipe, then the stoneware pipe from the water-closet has to be inserted into the socket of the iron soil pipe, and the joint made with cement.

The student should make a point of getting these methods of connections well grounded, as they are of very great assistance in some of the oral examiners' "posers."

Having discussed the various types of sanitary fittings, traps, connections, pipes, etc., let us now study the important part of assembling or putting together of those appliances we have been considering.

First, then, we will take water-closets. These should be erected in an apartment next to an external wall, and provided with a window, made to open, of not less area than two square feet.

The fitting itself should have placed underneath it a lead "safe," as described in a previous chapter, the overflow of this safe being carried through the wall and cut short.

The closet, having been secured to the floor and the outgoing pipe fitted into the socket of the soil pipe, if an iron one, or into the copper socket, if a lead one, should have its joint made as directed. Now we will turn our attention to the antisyphonage pipe. In most modern closets, we find the connection for this just above

the outgoing pipe or "horn" of the closet, and beyond the water seal. This connection takes a two-inch pipe which is carried through the wall.

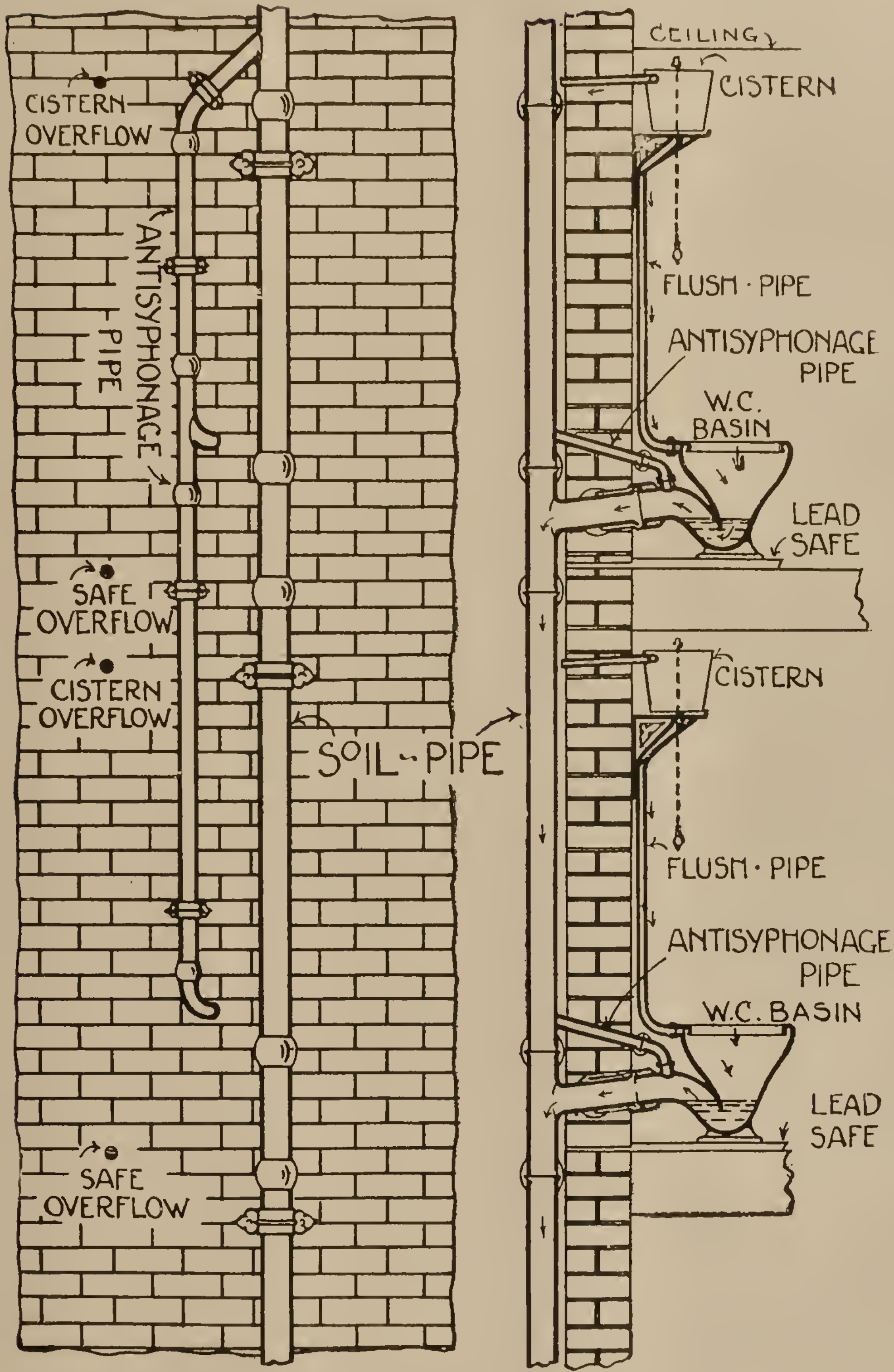
Should there be only one closet in connection with the soil stack, this antisyphonage pipe is carried in an upward direction for a short distance and then joined to the soil pipe. Should, however, there be more than one water-closet on the stack, then the antisyphonage pipe will be carried straight up, receiving the other antisyphonage pipes on its course until it reaches a point beyond the place where the topmost water-closet joins the soil pipe, where it may be joined into the soil pipe, or, if desired, continued upwards, finishing like the soil pipe at a point where it is clear of all openings to the house, and being provided with a guard of wire mesh on top. The cistern is fitted immediately above the water-closet as high as possible, and connected to the basin by means of a flushing pipe, a connection for which is provided at the back. This cistern is fed directly from the service water pipe, fitted with a ball valve, and has an overflow pipe which is carried through the external wall and cut short, although in some cases it is simply left with a turn-over sufficient to discharge any water, should there be an overflow, into the basin of the closet.

It should not be forgotten either with regard to the supply of water, that such must not be direct from a cistern for supply water for drinking or domestic purposes.

The seat is now fixed to the water-closet by two screws which have nuts and washers, and for which openings are left in the ledge at the back of the basin. Slop sinks are fitted in a similar manner to water-closets.

In Fig. 124 is shown a range or stack of water-closets with the various pipes and connections defined. Where closets are fitted of the old-fashioned type, the student will learn, of course, to look out for faulty connections between closet and soil pipe, no antisyphonage pipes, and in many cases the old-fashioned bellows regulator type of flushing appliance, while the convenience will also be cased in with woodwork.

With lavatories and washhand basins, the trap is usually of drawn lead made with a screwed access plug at its lower end, and having a connection for an antisyphonage pipe at the point beyond the seal of the trap. This trap is connected to the waste pipe according to the method laid down previously. The antisyphonage pipe is then carried from the top of the trap through the wall, and, if there are no other branches into the waste pipe at a higher level, it is carried up the wall a short distance and then connected to the waste pipe, or, if preferred, carried up to the top of the wall and a guard of wire mesh fitted at the top.



[ELEVATION]
SHOWING SOIL & ANTISYPHONAGE PIPES

[SECTION]
SHOWING ARRANGEMENT OF PIPES & CONNECTIONS

Fig. 124

Should there be a range of basins, the antisyphonage pipes from each trap may join into one common pipe fitted for the purpose as shown in Fig. 125.

With baths, these are usually heavy enough in themselves not to require any fixing to the floor.

In some instances a drawn lead trap is employed, in which case it is "vented" in a similar manner to that just considered in use with washhand basins. Recently, however, the general style of trap used in connection with baths is a form of anti-D trap, which, of course, is not fitted with an antisyphonage pipe.

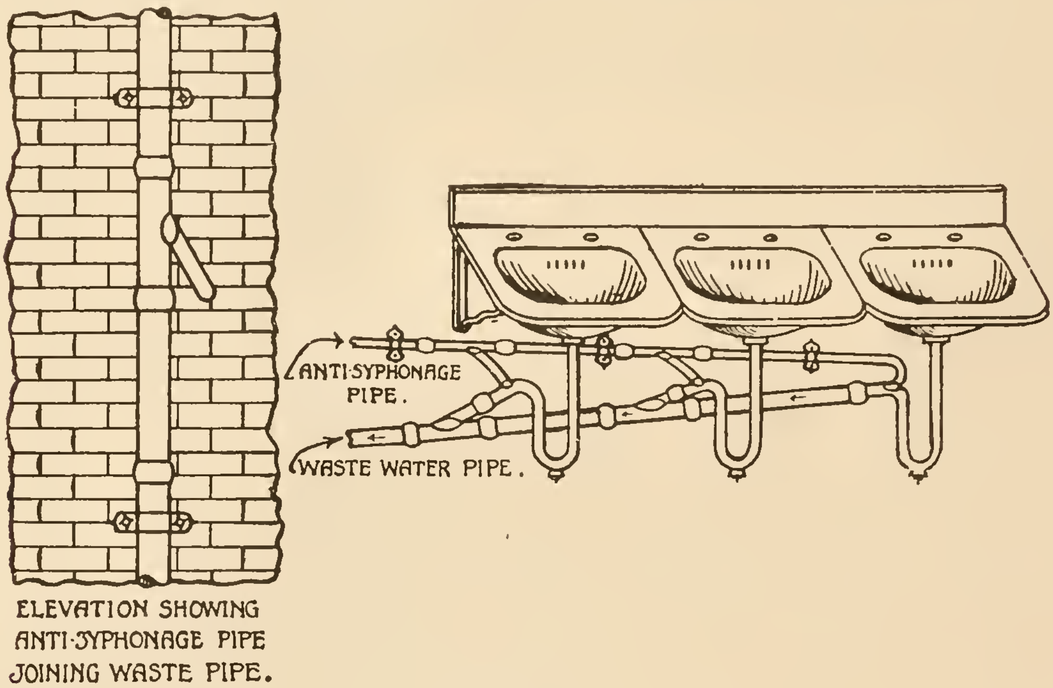


Fig. 125

In the case of sinks, these have a vent or puff pipe, carried from the top of the trap through the external wall to the outside air, cut short and finished with a hinged flap.

Before leaving this subject, it is as well to point out that pipes should not be used of too large a diameter. The following are some of the most suitable diameters for pipes :—

Soil pipe, 3½ inches (minimum).
Waste pipe, 2½ to 3 inches.
Antisyphonage to water-closets, 2 inches.
,, ,, for sinks, 1 inch.
Ventilation pipe at top of drainage system, 4 inches (minimum).

In conclusion, volumes could be written on defects of fittings and plumbers' work, as for instance in bad joints, faulty connections, the carrying of soil matters and waste from sinks and lava-

tories into one common waste pipe or stalk, the laying of drain pipes in the wrong way—with sockets in direction of flow of sewage instead of against it—traps placed in wrong positions, overflows of lavatories connected to opening left for antisyphonage pipe, and the cutting short of soil and waste pipes at the eaves, and so on; but if the student will get a good grasp of the right methods of laying drains, the proper place for traps, the proper kinds of joints and connections, the right kind of pipes and appliances to be fitted, and the correct method of fitting them, he will then very soon be able to detect not only bad fittings, but also bad workmanship, and everything that is undesirable and unsatisfactory. Get a good grasp, then, of what should be done, and what ought not to be done will soon be detected by you. As to tests for these fittings when erected, the smoke test, as already described, for drains is the best. Apply the machine at the bottom of the pipe, plug up the top end of the stalk, pump in smoke, and if there are any faulty joints or parts, the smoke will be seen issuing from them. Oil of peppermint diluted with hot water may also be used by pouring into a water-closet basin and flushing it over the seal, when the high smell of the peppermint will penetrate any leaks into the room. Unfortunately, in practice, the drawback is that the oil of peppermint adheres to the hands of the operator, and wherever he goes the smell will be found.

Then there is Kinggett's drain tester or "stinker," consisting of two metal cups or plates, inside of which is a chemical compound. The whole is surrounded by string; this string is undone, the end tied to the water-closet seat, and the metal part is dropped into the basin and carried beyond the seal by the flush. The water acting on the chemical causes a gas to be given off which escapes through any defects there may be in pipes, joints, or connections.

Chapter XVI

LAW RELATING TO WATER-CLOSETS, ETC.

Under the Public Health Act, 1875, Sections 35 to 41, we have the legal position with regard to water-closets, privies, etc.

By Section 35, it is illegal to build a new house or rebuild a house without sufficient water-closet, earth-closet, or privy accommodation, having proper doors and coverings.

In Section 36, power is given to a Local Authority to enforce the provision of water-closet or privy accommodation by the service of a notice on the report of their Surveyor or Inspector of Nuisances, and if the terms of such notice are not complied with the Local Authority may do the work and recover the expenses incurred, in a summary manner, or may declare such expenses to be private improvement expenses. This is a very important section in Sanitary Law, and by it a Local Authority may require a water-closet to be substituted for a privy should the latter in their opinion be insufficient ; and again, should a water-closet, earth-closet, or privy be used by the inmates of two or more houses, the Local Authority need not require a separate water-closet, earth-closet, or privy for each house.

With regard to earth-closets, Local Authorities may under Section 37 undertake to supply earth for same.

Section 38 deals with the provision of water-closets, earth-closets, etc., with regard to the separate sexes employed in any building used as a workshop or workplace, and empowers Local Authorities to serve notice for such provisions on the owners or occupiers of each building. Urban Authorities under Section 39 may provide places of public sanitary convenience and maintain the same ; while by Section 40, Local Authorities must see that nothing in the construction, or in the manner in which they are kept, tends to create a nuisance.

Section 41 is very important, and is as follows:—"On the *written application* of any person to a Local Authority stating that any drain, water-closet, privy, ashpit, or cesspool, on or belonging to any premises within their district is a nuisance or injurious to health (but not otherwise), the Local Authority may, by *writing*,

empower their Surveyor or Inspector of Nuisances, after 24 hours' written notice to the occupier of such premises, or in case of emergency without notice, to enter such premises with or without assistants, and cause the ground to be opened and examine such drain, etc. If the drain, etc., on examination is found to be in proper condition, he shall cause the ground to be closed and any damage done to be made good as soon as can be, and the expenses of the work shall be defrayed by the Local Authority. If the drain, etc., on examination appear to be in bad condition, or to require alteration or amendment, the Local Authority shall cause notice in writing to be given to the owner or occupier of the premises requiring him forthwith, or within a reasonable time therein specified, to do the necessary work; and if such notice is not complied with, the person to whom it is given shall be liable to a penalty not exceeding 10s. for every day during which he continues to make default, and the Local Authority may if they think fit execute such work and may recover in a summary manner from the owner the expenses incurred by them in so doing, or may by order declare the same to be private improvement expenses."

From this section it will be seen that the complaint must be in writing, and the Inspector should see to it that he has the proper consent of his board or committee in writing. Again, it is very important to see that the complaint is injurious, as this is a very knotty point when it comes to law.

Where Part III. of the Public Health Acts Amendment Act, 1890, Section 20, has been adopted, Urban Authorities may provide and maintain public conveniences, and may,

1st, Make regulations with respect to their management;

2nd, Let the same for any period not exceeding three years;

3rd, Charge fees for the use of water-closets.

No public convenience, except in a railway station, is to be erected without the permission of the Urban Authority.

By Section 21, a penalty is imposed on any person injuring or improperly fouling any sanitary convenience used in common by the inmates of two or more houses, and if in the opinion of the Medical Officer of Health or Inspector of Nuisances the walls, floors, seats, etc., are in such a state or condition as to be a nuisance or annoyance to any inhabitant of the district for want of proper cleansing, the users—any or all—are liable to a penalty not exceeding 10s. and a daily penalty not exceeding 5s.

Here power is given to prosecute tenants improperly using water-closets or not keeping them clean.

It is interesting to note that in Section 11 of this Act the definition of "sanitary convenience" includes urinal, water-closet, earth-closet, privy, ashpit, or any similar convenience.

Section 22 amends Section 38 of the 1875 Act, but the duties are imposed upon the Surveyor and not the Inspector of Nuisances.

The Model Byelaws as to Buildings issued by the Local Government Board, have the following recommendations with respect to water-closets, etc. :—

Byelaw 67.—Every person who shall construct a water-closet or earth-closet in a building shall construct such water-closet or earth-closet in such a position that one of its sides at the least shall be an external wall.

Byelaw 68.—Every person who shall construct a water-closet or earth-closet in connection with a building, whether the situation of such water-closet or earth-closet be or be not within such building, shall construct in one of the walls of such water-closet or earth-closet a window of not less dimensions than two feet by one foot, exclusive of the frame, and opening directly into the external air. He shall, in addition to such window, cause such water-closet or earth-closet to be provided with adequate means of constant ventilation by at least one air brick built in an external wall of such water-closet or earth-closet, or by an air shaft, or by some other effectual method or appliance.

Byelaw 69.—Every person who shall construct a water-closet in connection with a building shall furnish such water-closet with a separate cistern or flushing box of adequate capacity, which shall be so constructed, fitted, and placed as to admit of the supply of water for use in such water-closet without any direct connection between any service pipe upon the premises and any part of the apparatus of such water-closet, other than such cistern or flushing box.

He shall furnish such water-closet with a suitable apparatus for the effectual application of water to any pan, basin, or other receptacle with which such apparatus may be connected and used, and for the effectual flushing and cleansing of such pan, basin, or other receptacle, and for the prompt and effectual removal therefrom of any solid or liquid filth which may from time to time be deposited therein.

He shall furnish such water-closet with a pan, basin, or other suitable receptacle of non-absorbent material, and of such shape, of such capacity, and of such mode of construction as to receive and contain a sufficient quantity of water, and to allow all filth which may from time to time be deposited in such pan, basin, or receptacle to fall free of the sides thereof, and directly into the water received and contained in such pan, basin, or receptacle.

He shall not construct or fix under such pan, basin, or receptacle any "container" or similar fitting.

He shall not construct or fix in or in connection with the

water-closet apparatus any trap of the kind known as a "D" trap.

Under the Public Health (Scotland) Act, 1897, Section 29, Local Authorities may erect and maintain public water-closets, privies, and urinals, while under the same Section they may by written notice require the owner or occupier of any schoolhouse, factory, or building in which persons are employed in any trade or business, to provide within a time specified in the notice a sufficient number of water-closets or privies for the separate use of each sex. If the person responsible fails to comply with the notice, he shall be liable to a penalty.

By Section 30, a penalty is imposed on any one who shall wilfully damage or cause to be a nuisance any water-closet, earth-closet, etc., while Section 31 is a very important one and worth giving in full, viz. :—

"The following provisions shall have effect with respect to any water-closet, earth-closet, privy, or similar convenience used in common by the occupiers of two or more separate dwelling houses, or by other persons :—

"(1) If any person injures or improperly fouls any such convenience, or anything used in connection therewith, he shall for each offence be liable to a penalty not exceeding ten shillings.

"(2) If any such water-closet, earth-closet, privy, or similar convenience, or the approaches thereto, or the walls, floors, seats, or fittings thereof, is or are, in the opinion of the Local Authority or of their Sanitary Inspector or Medical Officer, in such a state as to be a nuisance or annoyance to any of the persons using or entitled to use the same, for want of the proper cleansing thereof, such of the persons having the use thereof in common as may be in default, or in the absence of proof satisfactory to the court as to which of the persons having the use thereof in common is in default, each of those persons shall be liable to a penalty not exceeding ten shillings, and to a penalty not exceeding five shillings for every day during which the offence continues after a conviction for the offence."

Under the Burgh Police (Scotland) Act, 1892, Section 110, the Local Authority, here called the Commissioners, may erect or continue public water-closets or earth-closets.

Section 246 of this Act empowers the Local Authority to serve a notice on the owner of any house to provide a water supply, with sink, waste pipe, etc., and also to provide a proper water-closet for the use of the inmates of such house, or they may by notice require the owner or owners of more than one house to provide a sufficient number of water-closets on stairs or other suitable position for the mutual use of the inhabitants of the houses.

This Section is further amended by the Burgh Police (Scotland) Act, 1903, Section 24, which imposes a penalty on the owners where the terms of the notice have not been complied with to provide water-closets.

By Section 255 of the Act of 1892, Local Authorities may by notice require owners of houses to substitute water-closets for privies, and the foregoing Section 24 of the 1903 Act imposes penalties for non-compliance.

Chapter XVII

PRIVIES AND ASHPITS

In Chapter xiii. we discussed the various types of water-closets used in connection with dwellings, but in many districts, and particularly rural areas, water-closets are the exception rather than the rule.

In such districts one finds what is known as the *conservancy* system in use, where the drainage only takes ordinary waste water and where excremental matters are received in pans in what are known as privies, and these pans are periodically emptied of their contents, which are used on the land as manure.

Privies, when properly constructed and given that attention which they require and demand, can be a very satisfactory convenience; but on the other hand if they are simply conveniences set down without regard to the position of the site, and constructed with an idea of costing as little as possible, and, worst of all, neglected after they are in use, then they very soon become very serious nuisances.

Generally speaking, privies are of two kinds, namely, those with fixed receptacles and those with movable receptacles. Again, we have the combination of a privy and midden or ashpit, but we will leave that just now and confine ourselves to the simple privy.

A very objectionable type of privy met with sometimes on old farms consists of a structure built over a small stream, and it only requires a look at the stream beyond the privy itself to see how insanitary and objectionable this type of convenience can be. The excremental matter in this case drops directly into the stream and is carried along, polluting not only the stream but also the subsoil water of the district. Should the farm derive its water supply from a shallow well, the chances then are that the water will be contaminated. This type of privy ought to be unhesitatingly condemned.

The common type of privy in connection with country houses consists of a structure of wood or brick, fitted with a box-seat arrangement, under which the excremental matter is allowed to collect, and from which it is removed by a flap door at the back.

In this case, one may find that the inner sides of the receptacle have been lined with sheet iron and the bottom fitted with a stone slab, but more often than not these precautions are not taken, with the result that the wood becomes soaked in time with urine and other offensive matter and the liquid filth contaminates the ground beneath.

In the more approved type of privy, we find a suitably constructed apartment which is fitted with a window for light and ventilation and which has a cement concrete floor, at least six inches above the surface of the surrounding ground, this being given a fall towards the door of the apartment. The inside of the walls should be rendered in cement so as to present an impervious surface. A box seat is provided, under which is placed the pail or box to receive the excreta ; the floor of this box should be slightly lower than the floor of the privy.

The pail or receptacle for the excreta is limited by the Model Byelaws to a capacity not exceeding two cubic feet ; whereas, in the case of the former privy with a fixed receptacle, eight cubic feet are allowed by the byelaws.

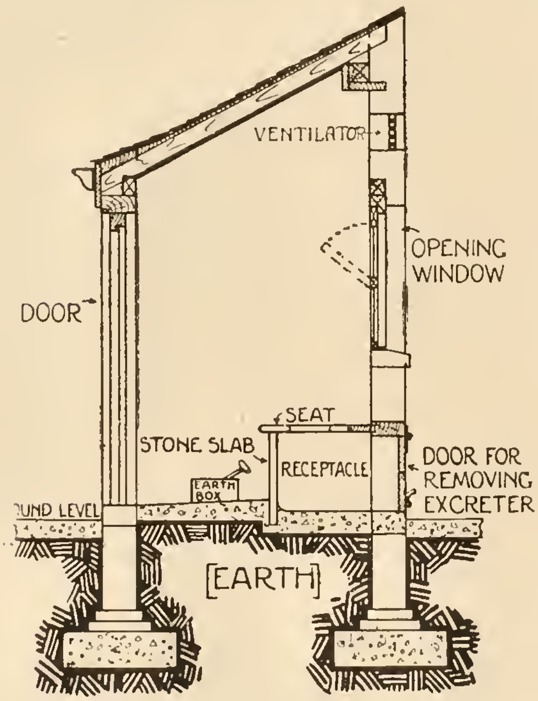


Fig. 126

Provision for removing the pail or other receptacle may be made by having the seat hinged, or by having a door on the ground level at the back or side of the apartment.

Now, let us take some practical applications of both these types of privies. In Fig. 126, we have a type of privy with fixed receptacle and known as an **Earth-Closet.**

Here the walls are of brick, coated internally with cement. The floor is of cement concrete, with a fall of half an inch to the foot towards the door of the apartment. This floor is six inches above the surrounding ground level.

The apartment is provided with a window, and also ventilated by means of ventilating bricks near the roof.

The front of the box consists of a stone slab extending across the chamber and fitted in to the sides, and the seat is of wood. At the rear of the privy, a hinged metal door is provided to facilitate cleansing. The receptacle or box is eight cubic feet, and the floor

of it is three inches lower than the floor of the privy itself. A box with scoop, containing dry earth, ashes, or other suitable absorbent material, is provided so that the excreta may be immediately covered after the privy has been in use. With a regular system of cleansing, and a sufficient supply of dry earth, this convenience can give a good deal of satisfaction. Modifications of this type of convenience have the earth applied by means of a mechanical spreader fitted to the seat. Again, some privies have an arrangement whereby household ashes are tipped into the receptacle from a shoot at the rear of the privy. Good earth, dry and finely sifted, is best for this purpose, and it should be distributed over the excreta, about a pint and a half to two pints being used on each occasion. The value of the earth in this case lies in the fact that not only does it retard decomposition but also disintegrates the organic matter with which it is mixed. Ashes, on the other hand, only assist in keeping the excreta dry, and so delay decomposition. The drawback with this system may be said to be in the length of time which elapses between the periods of cleansing, and for that reason the privy with the **Movable Receptacle**—with its limited capacity of two cubic feet, and consequent more frequent removal of excreta—must be said to hold the advantage.

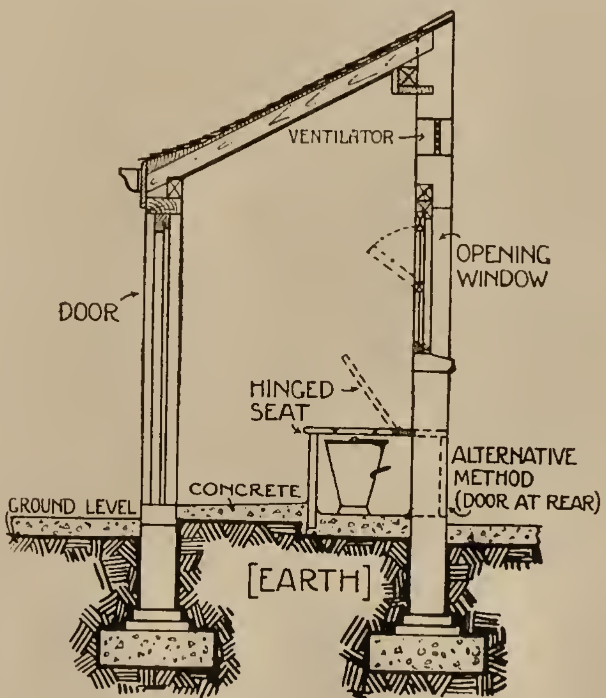


Fig. 127

In Fig. 127 is shown a convenience of this type. The structure is of similar construction to that of the earth-closet as regards walls, floors, windows, ventilation, etc.; but whereas the receptacle for the excreta in the first named occupies the whole space under the seat, in this case only a pail or special receptacle of the required dimensions is used.

These pails are removed frequently (daily in many districts), and are properly cleansed before being put down again, their place at the time they are removed being taken by a similar utensil. Many types of pails are used for the purpose, but it should always be seen that they be of good heavy galvanised iron, strongly made, and able to stand some service.

This conservancy system of privies is very useful in thinly

populated areas or country districts, if it is properly carried out as regards the construction and cleansing of the privies, but it can readily be understood that it is neither practicable nor desirable in towns.

We now come to another source of refuse which has to be dealt with, namely, **House Refuse.** The great difficulty with regard to this matter is that people will not stop to think of any plan for the disposal of house refuse other than putting it in the ashbin or ashpit, with the result that nuisances arise, and a great deal of bother and expense is created which could otherwise be avoided. House refuse consists of a miscellaneous collection of ashes, vegetable refuse, animal refuse, waste paper, food scraps, etc., and unfortunately the cause of much poverty is contained in these collections. The refuse may also contain old tins, bottles, jars, etc. The receptacles used for this refuse are privy middens, ashpits, and ashbins.

The **Privy Midden** shown in Fig. 128, and to which reference was made at the beginning of this chapter, is, as its name implies, a combination of a privy and a midden. These are to be found in most places where the conservancy system is in operation. They consist of an outbuilding of two apartments, divided by a brick partition.

The erection should be of brick, the walls being rendered internally with cement, and the floor of cement concrete. The floor of the midden, and portion of the privy under the seat, should be concave in shape, as in this way " matter " from the privy will fall into the midden. The midden is ventilated near the roof, and is provided with doors for allowing refuse to be deposited therein and also to facilitate cleansing operations.

In many cases, the midden part of this type of convenience is left uncovered, it being held that where ashpits are covered the interior of the midden soon becomes in a filthy state, but there is really no reason why such should be the case, as it is essential that the internal part of the midden should be periodically cleaned down. The important point in covering in these middens is, as already pointed out, to exclude heat from the sun's rays, and moisture from rain, etc.

In towns and districts where the conservancy system is not in operation, one of the oldest methods of providing for the deposit of refuse is by an **Ashpit.**

Sometimes these consist of sump holes dug in the ground and a rubble wall built around them. At best, this type is only a nuisance and a source of danger.

Later types are built in brick or stone slabs on a concrete bottom on the ground level. In some cases they are covered in,

in others the walls are carried about three feet high and finished with a cope. In other cases again, the ashpit is made of four stone slabs, set on edge in the form of a box, the bottom being of concrete.

All these types are usually drained to a gully trap outside the ashpit and connected to the drain, while an upstanding flush pipe

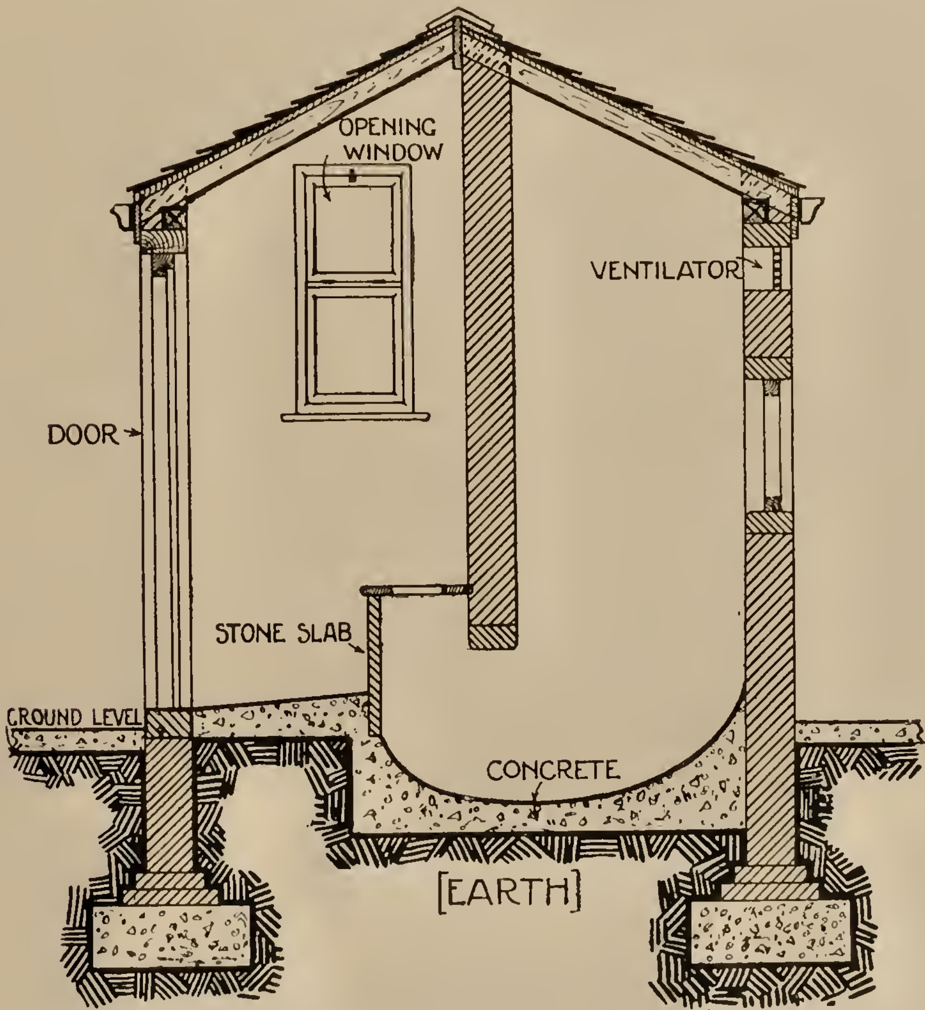


Fig. 128

with water cock is provided so that the ashpit may be freely flushed with water at regular intervals.

Other types of ashpits take the form of galvanised iron boxes fitted with sloping covers and sliding door on top for depositing the refuse, another door being provided at the bottom for cleansing purposes. This type, however, is not to be commended, as it soon becomes filthy and far from sanitary.

Ashpits are usually found in properties of the older type, particularly tenements in provincial towns where a large population has to be served by each convenience.

What is aimed at nowadays, however, for house refuse, is the **Ashbin** system. These ashbins are made of strong galvanised iron, and differ slightly in shape. Some are circular, with separate round lids, and some elliptical, with hinged sloping lids. They also vary in size according to whether only one house or more have to be served by the same ashbin. The lids and bottoms of the ashbins are often perforated with a number of holes : those in the bottom to allow of the escape of liquid matters, and those in the lid to allow of the escape of offensive odours. These precautions, however, are not altogether justifiable, as, in the first place, sanitarians aim at educating the people that "house refuse contains no liquids," and where water-closets are provided there is no reason for wet matter being introduced into the bin at all.

As regards the holes in the lid, we have already seen that our aim is to exclude damp, and for that reason the lids ought to be left whole.

So much, then, for the methods of depositing the refuse: let us now consider the means of collecting and disposing of same.

Chapter XVIII

COLLECTION AND DISPOSAL OF REFUSE

THE question of the collection and disposal of refuse is one which in large towns is under a special cleansing department in charge of a Cleansing Superintendent, but in smaller towns and country districts this work falls within the scope of the Sanitary Inspector's duties.

The question is one of considerable importance, and to assist in forming a rough estimate of the requirements of a given district, it is worth while pointing out that to deal with an area in which the conservancy system obtains, excremental matter equals a daily amount of 50 ounces of liquids and 4 ounces of solids for adults.

Taking children and others into consideration, one finds an individual average of 40 ounces of fluids and 2½ ounces of solids per day, or a quantity for the year equalling 95·25 gallons of liquid and 2 quarters 1 lb. of solids; or, with a population of 1000 inhabitants, one requires to provide for the disposal of 91,250 gallons of liquid and fully 25 tons of solids in a year. On top of this, there is the miscellaneous collection of household refuse and waste to be dealt with, so that it will readily be seen that a good deal of work and expense is involved in treating these matters.

With excremental matters from privies in country districts, the fæces are usually carted to a convenient manure heap and covered with a layer of earth to arrest decomposition and keep down offensive odours. In course of time it is worked in with the manure from stables and byres, and spread on the land for the cultivation of crops. Other refuse from middens in country areas is treated in a similar manner, any metal refuse being separated from it and buried or otherwise disposed of.

In town districts where the conservancy system is still in operation, special carts are provided for conveying the fæcal matter from privies to some place either for treatment or distribution. This cart removal method is not altogether satisfactory, a much better idea being to have the pans made with tight-fitting lids. At regular intervals these pans are lifted (the lids properly

fitted on) and carted away ; their place is then taken by other pans of similar dimensions.

This excremental matter has a ready sale as a fertiliser, either in its crude state or "treated." If the town or district served is within easy access of agricultural land, the disposal of the fæcal matter will present little difficulty. The important points to be attended to are, firstly, to see that no nuisance is created in dealing with the "matter," and secondly, to see that all pans are thoroughly cleansed and disinfected before returning to again do duty at the privies. Where means for disposing of this form of refuse is not so handy, the pails are removed to a central depot where the fæcal matter from them is transferred to specially constructed metal cylinders surrounded on the outside by a steam jacket, and the contents (by a process) are reduced to a dry powder, and in this form it finds a ready market as a fertiliser.

It will quite easily be understood that in the removal of excremental matter there is much to give rise to nuisances, and these must always be guarded against as far as possible.

Now, nuisances arise from the pails being allowed to become too full, due to the fact that the periods between removal are too long, or from pails being allowed to become faulty and leaky ; or again from the pails not being properly cleansed and disinfected when emptied. Nuisances may also be caused by carelessness in removing the pans from the privy and from not seeing that excremental matter does not find its way outside the pail when in position.

Attention to these points will do much to make the conservancy system tolerable ; neglect of them will soon make it unbearable.

In dealing with house refuse itself, apart from fæcal matters, one finds that a great deal of expense, worry, and nuisance could be avoided if more advantage be taken of the ordinary kitchen fire. In summer, when most housewives do without the aid of the kitchen fire, there is some excuse for much "matter," that would otherwise be better burned in the kitchen grate, finding its way to the ashbin ; but when a fire is burning in the house, even for a few hours, advantage of it should be taken to burn vegetable parings, waste paper, meat scraps, and garbage. Objection to this method, however, is often taken, because it is asserted that the smell from the burning "matter" is offensive. With a kitchen fire, especially a range, having a good draught, there is little likelihood of such a contingency having to be dealt with, and all sanitarians ought to make it a point of advocating this simple method of refuse disposal on every favourable opportunity.

However, we have to deal with matters as we find them.

Unfortunately, we find that the kitchen grate method is not generally applied, this resulting in miscellaneous collections of refuse.

With ashpits, such as have been described, the refuse is removed to the street by means of a barrow and collected by a cart. It is then driven to some depot or dump on the outskirts of the town.

In some localities one meets an important-looking notice board fixed on the top of a hollow piece of ground or sump hole with the words, "Rubbish may be shot here."

The idea is that any one may resort to this place and deposit their refuse. This is far from a satisfactory method, and the wonder is that any Local Authority should allow it. It is in this way that we get many of our "made" sites.

Where ashbins are in use, these may be either emptied in a cart and put back in their place, or they may be taken away full and their place taken by a fresh ashbin. This latter method is, of course, the better.

Nuisances may also arise in connection with the cleansing of ashpits and ashbins by careless and inefficient cleansing, the refuse not being lifted in a cleanly manner by the man in charge of the cart, and the place on the street where the refuse was becoming foul by liquid filth from the same. With ashbins, there is less likelihood of nuisance, provided that no liquid matters are introduced into them.

If liquids are put in, the bins quickly deteriorate, becoming faulty and leaky and the liquid causing the solid matters to adhere to the sides of the bin. This putting of liquids into the ashbins is the greatest obstacle in the way of success and desirability of the ashbin over other means of storage; only by educating people to the fact that by doing so they are causing trouble and inconvenience to themselves and others, besides being a probable source of danger, can we hope to make the scheme a success.

The refuse, having been removed to the dump or depot, is then sorted out. Rags, paper, cardboard, and old metal are put into separate heaps and disposed of, a use being found for the various materials, for which there is always a fair market. This practice, however, is not to be commended, and indeed should be discouraged from a health point of view. The remaining refuse is usually disposed of to farmers and others for putting on their land.

The ideal practice, however, is to destroy the whole of the refuse by burning in a destructor, perhaps the best-known type of which is what is known as "Fryer's."

This type of destructor is usually so constructed that a road

with easy gradient is provided for the dust-carts to reach an opening which communicates with a furnace where a fire is always burning. Here the refuse is tipped in and is soon burned. This furnace is usually connected with a boiler, and the heat from the cremated refuse is used to generate steam which may be used for a variety of purposes, among which is the driving of dynamos for the generating of electricity. The furnace is connected with a tall brick smoke stack. This smoke stack carries all gases of a likely offensive character to a sufficient height to render them harmless by diffusion with the air, and also provides the necessary draught for the furnace.

To sum up the whole business, it is not only highly desirable, but indeed essential, that with privies the excremental matter must be removed as often as possible, that good substantial pans be provided, and that, in cleansing, these be removed; when emptied at the depot, they should be thoroughly cleansed and disinfected. They should also be provided with close-fitting lids for the purpose of transit from the privy to the depot.

Now, ordinary house refuse should not be used to fill up ground hollows so as to provide sites, neither should it be sorted out and sold, but it should be cremated in a properly constructed destructor.

As to the removal of all refuse, great care should be taken to ensure that no nuisance is created either while in the ashpit or ashbin or when being removed from same.

The best method of storage for ordinary house refuse is the galvanised-iron dustbin, so constructed as to stand a good deal of wear and tear. The contents should be removed as often as possible, and the people prohibited from putting wet matters into the bin.

In the next chapter, it will be seen that there are certain legal requirements with regard to privies, ashpits, etc., which should be particularly noted.

Just one word in closing regarding carts used for removing refuse matter.

They should be strongly built and as watertight as possible around the joints and seams, while they should also be provided with covers, so that in windy weather the dust, paper, and lighter parts of the refuse may not be blown about so as to create a nuisance in the thoroughfares, etc.

Chapter XIX

LAWS AND BYELAWS REGARDING PRIVIES, ASHPITS, ETC.

THE law relating to this subject comes primarily under the heading of Scavenging and Cleansing, and is dealt with in Sections 42 to 50 of the Public Health Act, 1875; the principal sections being 43, 47, 48, 49, and 50.

Section 43 states—" If a Local Authority who have themselves undertaken or contracted for the removal of house refuse from premises, or the cleansing of earth-closets, privies, ashpits, and cesspools fail, without reasonable excuse, after notice in writing from the occupier of any house within their district requiring them to remove any house refuse or to cleanse any earth-closet, privy, ashpit, or cesspool belonging to such house, or used by the occupiers thereof, to cause the same to be removed or cleansed, as the case may be, within seven days, the Local Authority shall be liable to pay to the occupier of such house a penalty not exceeding five shillings for every day during which such default continues after the expiration of the said period."

This Section requires only one explanation, and that is with regard to the notice in writing. Thus, this notice should be sent to the Clerk of the Local Authority and not the Inspector.

Section 44 states that where the Local Authority do not undertake or contract for the removal of refuse or cleansing of privies themselves, they are empowered as to making byelaws and imposing the duty of cleansing on the occupier of the premises.

Section 45 empowers Local Authorities to provide proper receptacles for the temporary deposit of refuse.

Section 47 states:—" Any person who in any urban district—

(1) Keeps any swine or pig-sty in any dwelling house or so as to be a nuisance to any person, or

(2) Suffers any waste or stagnant water to remain in any cellar or place within any dwelling house for twenty-four hours after written notice to him from the Urban Authority to remove the same, or

(3) Allows the contents of any water-closet, privy, or cesspool to overflow or soak therefrom,

shall for every offence be liable to a penalty not exceeding forty shillings, and to a further penalty not exceeding five shillings for every day during which the offence is continued, and the Urban Authority shall abate or cause to be abated every such nuisance and may recover in a summary manner the expenses incurred by them in doing so from the occupier of the premises on which the nuisance exists."

It is not necessary under this section to prove that the nuisance is injurious to health, and it should also be noted that the person liable is the occupier, not the owner, of the property.

Under Section 49, the Inspector of Nuisances may give notice for the removal of any accumulation of manure, dung, soil, or filth or other offensive or noxious matter on any premises, and if at the expiry of twenty-four hours after such notice the accumulation is not removed, he may cause such offensive matter to be removed and sold, and should there be any surplus on such sale, it shall be paid to the owner of the refuse on demand, but should there be a deficit, then such deficit may be recovered from the owner of the refuse.

By Section 50, Urban Authorities may, by notice given by public announcement or otherwise, require the periodic removal of manure, etc., from mews and stables. Should the owner of such manure fail to comply with such notice, he will be liable in a penalty for neglect, without further notice from the Authority.

Under the Rivers Pollution Prevention Act, 1876, Section 2, it states :—"Every person who puts or causes to be put or to fall or knowingly permits to be put or to fall or to be carried into any stream, so as either singly or in combination with other similar acts of the same or any other person to interfere with its due flow or pollute its waters, the solid refuse of any manufactory, manufacturing process or quarry, or any rubbish or cinders, or any other waste or any putrid solid matter, shall be deemed to have committed an offence against this Act."

Under the Public Health Acts Amendment Act, 1890,—

Section 23 extends the provisions of Section 157 of the P.H.A., 1875, so as to empower every Urban Authority to make byelaws with regard to—among other things—"the provision in the connection with the laying out of new streets of secondary means of access where necessary for the purpose of the removal of house refuse and other matters."

By Section 24, we have an important ruling regarding privies, and we shall take it verbatim, thus :—

(1) "Where any portion of a room extends immediately over any privy (not being a water-closet or earth-closet), or immediately over any cesspool, midden, or ashpit, that room, whether built before or after the adoption of this part of this Act, shall not be occupied as a dwelling place, sleeping place, or workroom or place of habitual employment of any person in any manufacture, trade, or business during any portion of the day or night."

(2) "Any person who after the expiration of one month after the adoption of this part of this Act, and after notice from the Local Authority of not less than seven days, so occupies, and any person who suffers to be so occupied, any such room, shall be liable to a penalty not exceeding forty shillings and to a daily penalty not exceeding ten shillings."

Here, then, Urban Authorities who have adopted this Act can adopt prompt measures for dealing with rooms situated over privies, and so getting rid of what might otherwise be a serious menace to the health of the inmates of the room in question.

By Section 25 a penalty is imposed on any one erecting any new building on ground which has been filled up with refuse or any matter impregnated with fæcal or animal matter, unless such matter has been removed or rendered innocuous.

Section 26 contains a few important provisions, and is worth quoting in full. It is as follows :—

"(1) An Urban Authority may make byelaws in respect of the following matters, namely :—

(*a*) For prescribing the times for the removal or carriage through the streets of any fæcal or offensive or noxious matter or liquid, whether such matter or liquid shall be in course of removal or carriage from within or without or through their district :

(*b*) For providing that the vessel, receptacle, cart, or carriage used therefor shall be properly constructed and covered so as to prevent the escape of any such matter or liquid :

(*c*) For compelling the cleansing of any place whereon such matter or liquid shall have been dropped or spilt in such removal or carriage.

"(2) Where a Local Authority themselves undertake or contract for the removal of house refuse they may make byelaws imposing on the occupier of any premises duties in connection with such removal so as to facilitate the work which the Local Authority undertakes or contracts for."

Coming now to the Model Byelaws made by the Local Government Board with regard to New Streets and Buildings, we note the following important recommendations:—

Byelaw 70 requires every person who shall construct an earth-closet in connection with a building to provide a suitable receptacle of adequate capacity for dry earth or other suitable deodorising substance, and provide in connection with same some effective means for the effective application of a sufficient quantity of dry earth to any filth, etc., which may from time to time be placed in the pit, pan, or other receptacle used in connection with such earth-closet.

Byelaw 71 provides for the erection of all earth-closets to be outside the building for which they are intended, and that they be constructed so as to admit of ready access for the purpose of removing the contents. It also stipulates that where an earth-closet is constructed to contain filth and dry earth for a period not exceeding *three months*, the capacity of such earth-closet shall not exceed *forty cubic feet*.

. The receptacle for the filth must be so constructed as to prevent the absorption by any part of it of any filth deposited therein, and also so as to prevent the escape by leakage, etc., of any of its contents. He shall also construct such receptacle that the bottom or floor of it shall be at least *three inches* above the surface of the adjoining ground, and in such a fashion that the contents of the receptacle are not at any time exposed to the rainfall or the drainage of any waste water or liquid refuse.

Byelaw 73.—This deals with earth-closets constructed within a building, and stipulates that these must be provided with a movable receptacle for filth which must not be larger than of a capacity of *two cubic feet*; such receptacle to be so fitted that there is no possibility of the filth falling upon the floor or sides of the space beneath the seat, and also for provision being made for the application of dry earth to the filth from time to time.

Byelaw 74 deals with the erection of privies, and stipulates that they be at a distance of......feet from the dwelling. (*N.B.*—The distance is optional to the Local Authority adopting the byelaws, and for that reason is left blank. Six feet is what some Authorities lay down.)

Byelaw 75 stipulates that a privy must not be erected within......feet of any well, spring, or stream of water used or likely to be used by man for drinking or domestic purposes. (*N.B.*—Here again the distance is left blank; the usual distance is 50 feet.)

Byelaw 76 provides for all privies being so erected that they are easy of access for purposes of cleansing, and so built that the

filth when being removed from them does not need to be taken through any house or building.

In *Byelaw* 77 it is stated that all privies must be ventilated as near the roof as possible with a sufficient opening, that the floor be flagged or paved with hard tiles or other non-absorbent material, and that such floor be of a height of at least *six inches* above the surface of the ground and given a fall towards the door of *half an inch to the foot.*

Byelaw 78 specifies that in privies with a movable receptacle for filth, the space beneath the seat shall have a similar floor to the privy itself, such floor to be at least *three inches* above the ground level. The space itself to be of flagging, slate, or good brickwork at least nine *inches* thick, and rendered in good cement or asphalt.

The receptacle for such privy shall be of a capacity not exceeding *two cubic feet,* and shall be so fitted that fouling of the floor or walls of the space beneath the seat will not take place. Further, the seat shall be so constructed, or other provision made, to allow of the easy removal or adjustment of the receptacle for filth.

Byelaw 79 treats with privies made to receive refuse, dry ashes, etc., and requires that such receptacle shall be protected from rainwater or drainage of waste water or liquid filth. The receptacle must be so constructed that no absorption of filth will take place or the leakage of any liquid matter. The receptacle itself shall not exceed in this case a capacity of *eight cubic feet.*

Byelaw 81 specifies the distance an ashpit must be from any dwelling, while *Byelaw* 82 specifies the distance it must be from any well, spring, or stream of water.

Byelaw 83 provides for ashpits being so constructed as to allow of easy access for depositing of refuse and of cleansing, and stipulates that, in cleansing, such refuse is not to be taken through any house or public building.

By *Byelaw* 84 no ashpit shall exceed a capacity of *six cubic feet.*

Byelaw 85 requires ashpits to be constructed of flagging, slate, or good brickwork at least *nine inches* thick and rendered inside with cement or asphalt. Such ashpit shall be roofed over and ventilated, and furnished with a suitable door which can be securely closed to prevent the escape of any of its contents.

Byelaw 87.—Where a movable ashpit is provided, it should be constructed of galvanised iron or other suitable materials. Such ashpit shall be provided with suitable handles and a properly fitting cover, and be of a capacity not exceeding *six cubic feet.*

In the Local Government Board's Byelaws made in respect

of nuisances arising from snow, filth, dust, ashes, and rubbish, we find the following :—

No. 5.—The occupier of any premises must deposit any filth, dust, ashes, or rubbish in a proper receptacle when it is necessary to put such filth, etc., on any footway, pavement, or carriageway.

No. 6.—The occupier of any premises within twenty yards from the street or from any building or premises used for human habitation or school or place of public worship, or any factory, etc., shall not cause, without reasonable excuse, any privy, cesspool, etc., to be cleansed except between the hours of six o'clock and half-past eight o'clock in the morning during the months March to October, and seven o'clock and half-past nine o'clock in the morning during the months of November, December, January, and February.

No. 7 requires all receptacles for the removal of refuse, including carts, to be provided with proper covers to prevent the removal of such refuse causing a nuisance by spilling, slopping, or blowing about, and should there be any spilling or slopping, the person in charge will immediately thereafter thoroughly cleanse the place.

No. 8.—Any person receiving within the district any consignment of refuse or filth in the process of transit may deposit such filth for a period not exceeding *twenty-four* hours on a suitable piece of ground at least *one hundred yards* from any street or building.

No. 9.—Every person who shall deposit any filth from any cesspool or privy, which has not been properly deodorised, within *one hundred yards* of any street or building, and which is intended for agricultural purposes, shall with all reasonable despatch cause such filth to be ploughed or dug into the ground, or adopt such other measures so as to effectually prevent the emission of any noxious or offensive effluvia from such filth.

No. 10.—No person shall deposit or unload any filth within *one hundred yards* of any street or building for the purpose of being removed therefrom.

No. 11.—Where such filth has to be deposited temporarily within one hundred yards of a street or building, such filth must be covered forthwith with a sufficient coating of earth or other suitable substance, or such other precautions adopted to prevent the emission of noxious or offensive odours.

No. 12.—Where it is necessary to convey through any street any filth emitting a stench, such shall be covered with a layer of lime or other suitable material to prevent the emission of effluvia.

No. 13 deals with the distance pig-sties must be from a

dwelling house, and the disposal of swine's dung. Pig-sties must be maintained in a cleanly state.

No. 14.—Cattle or swine dung not to be kept in such a position or such a manner as to pollute water supply.

No. 15.—Proper provision to be made for the reception of all animal dung. The floors of these not to be lower than the level of adjoining ground, and the receptacle so constructed as to prevent the escape or leakage from it of any liquid filth, or soakage into the ground. Receptacle to be provided with suitable cover and be properly drained, and the owner of the animals shall cause such dung to be removed at least *once every week.*

The law in Scotland regarding Scavenging and Cleansing is contained under that head in Sections 38 to 42 of the Public Health (Scotland) Act, 1897.

By Section 44 of the Local Government (Scotland) Act, 1894, powers were given district committees and county councils, on a requisition from the parish council, or ten electors, to form special scavenging districts.

Section 38 of the Act we are now considering gives power of appeal against such action.

Section 39 is of little importance to us, and deals with the scavenging of highways.

Section 40 empowers Local Authorities to remove any filthy bedding, clothing, etc., and limewash and purify any house or part thereof which is in a filthy or unwholesome condition.

Section 41 deals with the cleansing of offensive ditches near to or forming the boundary of a district.

Section 42 empowers local authorities, by giving notice, to arrange for the periodical removal of manure from mews and other premises.

Under the heading of Cleansing, the Burgh Police (Scotland) Act, 1892 (Sections 107 to 127) :—

Section 107 defines all dung, ashes, rubbish, filth, manure, night soil, etc., as being the property of the Commissioners, who may by Section 108 provide lands, etc., for the deposit of such materials.

Section 109 prescribes the method of removal of refuse, by properly covered carts, etc., and Section 112 empowers the Local Authority to engage scavengers to do this work, while by Section 113 a penalty is inflicted for obstructing a scavenger in the execution of his duty.

Under Section 114 it is a punishable offence for any person other than a scavenger to remove refuse, etc., without the permission of the Commissioners.

By Section 122, horse and cow dung must be kept off the

streets, and regulations may be made by Commissioners under Section 123 with regard to the regular cleansing of dungsteads.

Section 124 fixes the time of removal of dung, etc., through the streets of the town, while Section 125 inflicts a penalty for doing so at improper times.

Section 126 deals with the laying down of manure or dung on any field, garden, ground, or nursery, and if on a certificate of the Medical Officer of Health such deposit is said to be offensive or prejudicial to health, the Magistrate may order its removal or have it disposed of otherwise.

Section 127 empowers the Commissioners to make Byelaws regarding the preceding Sections.

It should be pointed out that all the Byelaws of the Local Government Board apply also to Scotland.

Chapter XX

TREATMENT AND DISPOSAL OF SEWAGE

In this chapter we shall deal with the very important and interesting question of how the sewage of any town or district is treated or disposed of.

In a previous chapter we have dealt with drains and sewers, and now we come to the various methods in operation for the final disposal of the contents of these.

The methods employed include the following systems, viz.: Discharge into the sea, broad irrigation, sub-irrigation, precipitation, filtration, electrolysis, and bacteriolysis.

As will be seen in the next chapter, it is illegal to discharge any sewage into a stream until it is purified or rendered harmless; under these circumstances, therefore, Local Authorities of inland towns have no alternative but to undertake some form of works for the purification of sewage.

Some of our towns, such as those situated on estuaries of large tidal rivers or on the coast, are fortunate, in that they can carry the outfall of their sewers into the tidal waters at a point below high-water mark. Thus, with the exception of the initial cost of carrying the pipes out, and the small outlay for upkeep, they get rid of all sewage matter with little trouble, inconvenience, or expense.

But other towns are not so fortunate, and any of the foregoing systems may be found in operation for the purpose of sewage purification. Let us take these systems in the order given, and discuss their respective methods of working.

Among the earlier methods of sewage disposal advocated by sanitary engineers was that known as **Broad Irrigation.** This method consists of carrying the sewage by means of open carriers, from the end of the sewer on to the land to be irrigated. The first requirement is a sufficiently large-sized area of suitable soil on which crops can be grown. The sewage, as stated, is led on to the land by an open carrier and branch carriers, and then by trenches and furrows over the land itself for distribution. Here the sewage is used as a fertiliser for whatever crops are grown on the ground,

and it was hoped that by this means of sewage disposal, not only would a satisfactory means of treatment be established, but that the revenue from the crops raised from the sewage would more than repay the expense incurred in connection with the work. It was found that the success of the system depended on the nature of the soil, the volume of sewage to be treated, the area for distributing purposes, and the care given to the working of the system and the raising of the crops. It was found also that floods, heavy rainfalls, and, in winter, the frost played havoc with the easy working of the system, while in time the ground itself soon became "sick" with the continuity of the treatment. Some of these sewage farms have been worked in such a way as to give a fair measure of satisfaction and without creating any nuisance, and a few have realised the hope of the produce from such farms covering the expense of working, but these latter are few indeed, and as a result other methods of disposal have been adopted.

Where only a comparatively small quantity of sewage has to be treated, a modification of the foregoing method is frequently employed, namely **Sub-irrigation.** Now, this system also requires land for the purification of the sewage.

In this case, the crude sewage should not be applied direct to irrigation, but a tank ought to be introduced near the outfall of the sewer. This tank receives the sewage and liquefies it. The liquid sewage is then carried along to a central chamber or large manhole, and to this chamber a series of branch drains are connected which conduct the sewage, by means of field pipes, through the soil.

Where the volume of sewage to be dealt with is not too large, and suitable ground such as grass land, orchards, etc., is available, this system can be worked very successfully, especially if an intermittent method is adopted so that a section, or sections, may be rested occasionally.

It ought to be mentioned that the field pipes used are the ordinary unglazed agricultural pipes, which are unjointed and laid near the surface of the ground.

With this system, there is less liability of nuisance than with the former, and less trouble with frost.

Where larger volumes of sewage have to be treated than it would be possible to undertake by the sub-irrigation method, we find the **Subsidence** method, latterly superseded by the **Precipitation** system, very much in favour.

It was found, however, that when the sewage was allowed to stand in tanks for a time, it gradually became more liquefied. This method, which is sometimes met with, is known as the subsidence system. It was also found that by the addition of certain

chemical precipitants, the solid matters could be more quickly broken up and disintegrated, and consequently the sewage more expeditiously dealt with. Tanks for the treatment of sewage were at first of shallow design, but later types, such as the Dortmund Tank and others, are of deep design. Where this system is in operation, the sewer is led into a chamber near the tank. From the

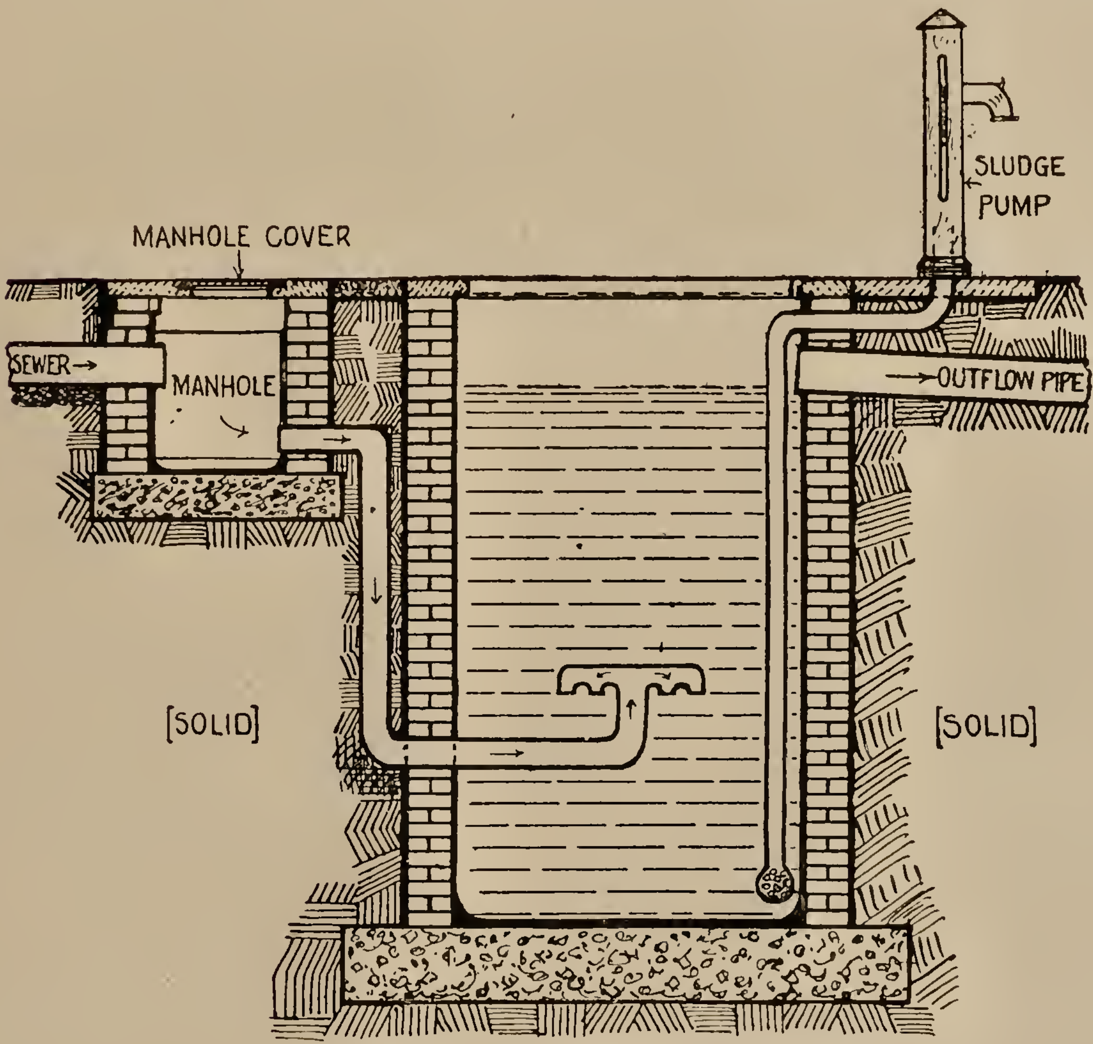


Fig. 129

bottom of this chamber a pipe is carried down to about three-fourths of the depth of the tank, and here it enters the tank and branches off in a series of arms, the idea being that, in this way, the sewage will not enter with too great a force and disturb the settling process of the sewage already in the tank. In Fig. 129, we have a representation of how the tank is constructed. The chemicals used in the process are added to the sewage in the tank, and these agents act on the solids and matter in suspension and carry them down to the bottom of the tank in the form of what is known as

"sludge," leaving the sewage in a comparatively clear liquid state. It must not, however, be supposed that this clarified sewage is sufficiently pure to warrant its being discharged into a river or stream; a further process of filtration, or some other method, is required to complete the system. Now, the chemical precipitants used are lime, alum, salts of iron, herring brine, etc. To complete the process, the effluent is passed over a filter of coke or some other filtering medium.

The sludge, which settles at the bottom of the tank, requires to be removed periodically. In some cases, sludge-pumps are fitted to the tank, and by this means the tank may be kept fairly clear. The disposal of the sludge is another aspect of the system which presents itself. Where land used for agricultural purposes is convenient, the sludge may be carted away and used on the fields as manure, provided no nuisance is created in so doing, or it may be burned and manufactured into a cement. A good deal of care will have to be exercised in the selection of a precipitant if the sludge is to be afterwards used as a fertiliser, as certain chemicals destroy the value of the sludge for that purpose. In some places, London for example, the sludge is taken out to the sea in barges and dumped.

Whether the system adopted consisted of the subsidence or precipitant method, it was found that **filtration** of some kind was necessary. In some cases, the effluent was filtered by irrigating land, but the most popular form was by constructing sewage filters.

Sewage filters are constructed on similar lines to water filters, only that different materials are used. These materials consist of coke, coal breeze, coal, slag, refuse from potteries, ballast and, in some cases, proprietary matters.

After much experimenting and experience, however, it has been found that the chief properties required of a filtering medium for this work are hardness, non-friability, and stability, and that good results may be obtained from such materials as burnt ballast, clinkers, broken gravel, and shingle, granite, etc.

These filters are used in two different ways. In one, the sewage is regulated to pass through the filter in a volume which will not cause water-logging. Thus, in this case the filter bed is in operation continuously. In the second, however (known as the *contact bed*), the sewage is run into the filter until it is full and allowed to stand for, say, two or three hours, when the outlet is suddenly opened, and the sewage speedily run off, after which the filter is allowed to stand for a set period to allow of aeration. These filters are now made with some mechanical apparatus for distributing the sewage over their surface. In some cases, the

Fiddian distributor is employed. In this case, the filter bed is circular and the sewage enters by a pipe in the centre and is carried along an arm which extends to the outer edge or circumference of the filter ; this arm is fitted with a mechanism for equally distributing the sewage received from the central feed pipe. Here, the motive power for driving the mechanism is the sewage itself.

Other types of filtration plant are the Candy Craik Sprinkler, Stoddart's Simple Distributor, Adams' Timed Syphon, and others.

Another method which has been tried is that of Webster's process of purification by **Electrolysis.** By this method, strong electrical currents were passed through the sewage and found to produce a high state of purification. The drawback to this system, however, is that it is a very expensive one to put into practice.

We now come to the most popular method of the treatment of sewage, known as **Bacteriolysis,** which is really nothing more or less than the encouraging of the growth of micro-organisms in the sewage by placing it under as favourable conditions for that purpose as possible.

The organisms contained in the sewage may be divided into two classes, viz. anaerobic and aerobic. To promote the growth of the first named, light and air must be excluded, when the organisms will grow rapidly and decompose the organic matter in the sewage, reducing it to CO_2, ammonia, water, and various gases. After this stage of liquefaction, the effluent is run on to a filter bed where aerobic action takes place and the sewage finally purified. Fig. 130 shows a fairly common form of *septic tank*, which is a practical application of the Bacteriolysis method. Thus, the following is a brief description of plan and method of working. First, however, it is necessary that the tank should be capable of holding the maximum number of days' supply of sewage for the area. In this way, we can ensure that the flow of sewage through the tank or tanks will be slow. The tank must be impermeable and air-tight, and should be situated wholly underground. It may be built of stone, brick, or concrete, rendered internally with cement, the roof being of concrete, and, if desired, covered with turf. In short, it is simply a perfected form of cesspool. The sewage enters a detritus chamber first, this being three feet deeper than the tank itself and provided with a storm overflow for excess of storm water. From this chamber, the sewage enters the tank by two openings placed about five feet below the level of the tank sewage, so as not to disturb the contents or the tank of the scum on top of the sewage. Thus, there is no backward escape of gas from the tank, and no air is carried into it. The effluent flows gently through the openings, which consist of slots running the whole length of the end wall of the tank. In some cases, a brick inspec-

tion well is built into the centre of the tank. This well is fitted with plate-glass windows through which the bacterial action can be watched. The sewage must remain in the tank for 24 hours to get full benefit. Now, the tank requires some time to attain maturity, but, once started, it goes on continuously. There is a constant agitation going on in the tank, masses of sewage rising and falling owing to gas production and bubble bursting. Thus, a gradual breaking up of the solid particles of the sewage takes place, and a thick scum forms on the surface. This scum should

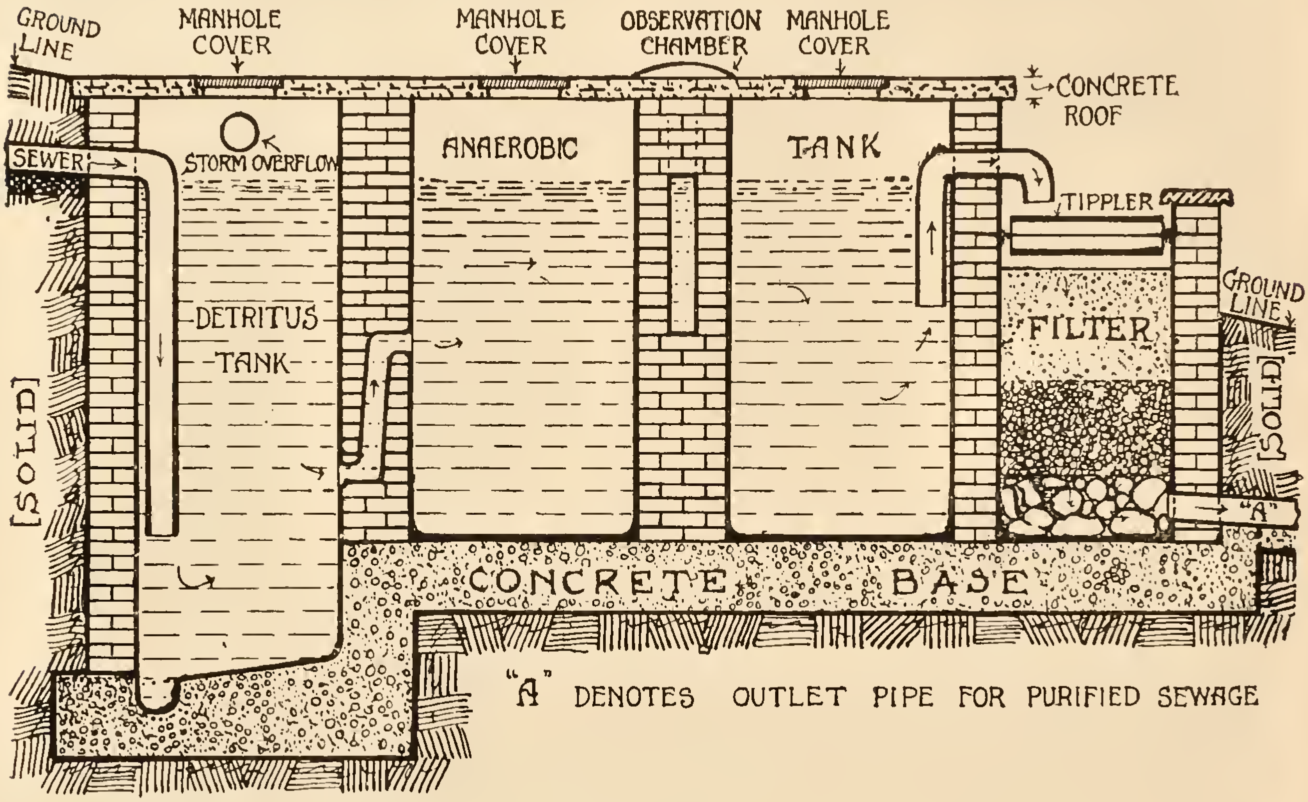


Fig. 130

not be removed or broken, as it is very essential to the success of the process. The organic matter is in part dissolved, and in part resolved into gases, and there is a slight deposit of sludge with sand, grit, etc. The gases produced, and which fill the upper part of the tank, are sulphuretted hydrogen, carbonic acid, carbonetted hydrogen, nitrogen, and marsh gas. The outlet pipe from the tank is made to carry off the effluent some distance below the surface of the sewage in the tank, and the now liquefied sewage passing through this pipe resembles ditch water. This is then run on to filter beds, where the further action by aerobics takes place in the open. As already stated, the materials for these filters, provided they comply with the requirements given earlier in the chapter, are unimportant, but the filters should be constructed in series so

that they may be rested occasionally for aeration. Some of these filters consist of crushed furnace clinker 4 feet 6 inches deep, resting on a bed of coarse gravel 6 inches deep. After passing through the filter, the effluent is clear and sparkling, and may be discharged into any stream, etc., with absolute safety. Sometimes we find a combination of systems on septic tank lines such as the **Dibdin System**, where a contact bed is provided in place of a tank. This bed, which is to all intents and purposes a tank, is filled with coarse ballast, clinker or coke, the sewage being run in until the bed is full, allowed to stand for a specified time, and then run off, the effluent being treated in the same way as above described. With the **Scott-Moncrieff System** (which is also worked on the contact bed method), the sewage is run in at the bottom of the tank and the effluent passed through a filter consisting of a layer of trays, the one over the other.

Weighing up the merits and demerits of the various systems just discussed, one must admit that the septic tank method, either by itself or in combination with the contact bed or similar method, is the best.

Sewage generally may be said to consist of water which contains certain refuse matters either in a solid or soluble state; usually these consist of urine and excremental matters, house waste water containing grease, soap, floor washings, foul water from baths which contains effete matter from the surface of the body, waste waters from laundries, and certain refuse matters from manufactories.

Sewage very quickly decomposes, and this is where nuisance arises. In its fresh state, sewage is really harmless, even although it is difficult to convince some people of this fact. In dealing with sewage, we take advantage of the putrefaction in it as an aid to its treatment. This putrefaction, or, in other words, fermentation, is really the bacteria contained in the sewage itself attacking and breaking up the organic matter contained therein, and we have already seen how this element has been turned to advantage.

It must be clearly understood that it is not sufficient to simply clarify the sewage, as we know that even water though bright and sparkling may be highly polluted; therefore, before the effluent of any sewage scheme is discharged into any stream or river, it is necessary that all dangerous organic matter should be rendered harmless and converted into inorganic substances by some reliable tested method of sewage treatment, and that the effluent contains nothing of a polluting nature or which would contaminate the stream into which it is discharged.

Chapter XXI

LAW REGARDING SEWAGE DISPOSAL

UNDER the heading of Disposal of Sewage, Sections 27 to 34, the Public Health Act, 1875, deals with the legal aspect of this matter. Under Section 27, we have the following powers for the disposal of sewage :—

"Section 27.—For the purpose of receiving, storing, disinfecting, distributing, or otherwise disposing of sewage any Local Authority may :—

(1) Construct any works within their district, or (subject to the provisions of this Act as to sewage works without the district of the Local Authority) without their district ; and

(2) Contract for the use of, purchase, or take on lease any land, buildings, engines, materials or apparatus, either within or without their district ; and

(3) Contract to supply for any period not exceeding twenty-five years any person with sewage, and as to the execution and cost of works either within or without their district for the purpose of such supply ;

Provided that no nuisance be created in the exercise of any of the powers given by this Section."

Here, then, we have our authority for constructing any such works either within the district, or without the district with the consent of the Local Authority for the district where it is intended the work should be; or should it be desired, the Local Authority may contract with any person or company to dispose of such sewage.

In Section 28, two or more Local Authorities may, with the approval of the Local Government Board, unite together for the disposal of the sewage from their collective districts, while in Section 29 powers are conferred on local authorities to deal with any land appropriated for the treatment of sewage "in such manner as they deem most profitable," and they may either lease such ground for agricultural purposes for a period not exceeding twenty-one years, or they may contract with any person to take the

produce of such land in whole or in part, or they may farm the land themselves, provided that all sewage brought to the land shall be effectually disposed of without creating a nuisance. By Section 30, the Local Authority, where they have come to an agreement with any person concerning such work, may contribute towards the cost of carrying such work into execution.

All such work shall be deemed, under Section 31, to be an improvement of land authorised by the Improvement of Land Act, 1864.

Section 32 stipulates for three months' notice to be given of the intention of Local Authorities to do such work, and shall name a place where a copy of the plan of any such work is open for inspection at all reasonable hours.

Should any objection be lodged against such work then under Section 33, the work shall not be proceeded with until the sanction of the Local Government Board is given after an inquiry shall have been held into the matter, or until the objection has been withdrawn.

By Section 34, the Local Government Board may, on the application by the Local Authority, appoint an Inspector to make an inquiry on the spot into the nature of the intended work—the Inspector to report to the Local Government Board the result of his inquiries.

Going back to Section 17 of this Act, it is explicitly stated that all sewage must be purified before being discharged into any stream, watercourse, canal, pond, or lake, while power is given in Section 69 for any Local Authority, with the sanction of the Attorney-General, for the taking of proceedings to protect any watercourse within their district from pollution by sewage, etc.

By the Local Government Act of 1888, the duty of enforcing the provisions of the Rivers Pollution Act was conferred on County Councils, and in this way a large measure of responsibility for the purity of our streams and waterways was thrown on these bodies.

By Section 2 of the Rivers Pollution Prevention Act, 1876, it is prohibited to put any solid refuse, etc., into any stream.

Under Section 3, Part III. of the Act, it is an offence for any person to cause to fall or flow into any stream any solid or liquid sewage, and, in the event of sewage being discharged into any stream at the passing of this Act, the person responsible for such discharge of sewage shall not be convicted if he prove to the satisfaction of the court that he is using the best practicable and available means to render such sewage harmless. The Local Government Board after local inquiry may grant an extension of time to any Sanitary Authority to adopt the best practical and available means of dealing with the sewage under their control.

By the Act of 1893, this Section is extended as follows :—

"Where any sewage matter falls or flows or is carried into any stream after passing through or along a channel which is vested in a Sanitary Authority, the Sanitary Authority shall, for the purposes of Section 3 of the Rivers Pollution Prevention Act 1876, be deemed to knowingly permit the sewage matter so to fall, flow, or be carried."

Under Section 4 of the Act of 1876 it is an offence for any person to cause to fall or flow or be carried into any stream any poisonous, noxious, or polluting liquid proceeding from any factory or manufacturing process; but should the person charged prove to the satisfaction of the court that he has used the best practical and available means for rendering such liquid harmless, there shall be no conviction.

Under Section 5 it is an offence for any person to allow to pass into any stream any solid matters or any poisonous, noxious, or polluting solid or liquid matter proceeding from any mine, other than water in the same condition as that in which it has been drained or raised from such mine, unless he can prove that such poisonous, noxious, or polluting matter has been rendered harmless.

By Section 6, proceedings can only be taken by a Sanitary Authority. Section 7 permits Local Authorities to allow sewage to enter sewers provided no injury is done to sewer or sludge.

Under Section 12, a certificate of best means available for treatment of sewage may be obtained from the Local Government Board Inspector. This lasts for two years, and the applicant pays for it.

By Section 20, we get the following definitions :—

"Stream" includes the sea to such extent, and tidal waters to such point, after local inquiry, and on sanitary grounds, as determined by the Local Government Board and by order published in the *London Gazette.* Save as aforesaid, it includes rivers, streams, canals, lakes, and watercourses, other than watercourses at the passing of this Act mainly used as sewers and emptying directly into the sea or tidal waters which have not been determined to be streams within the meaning of this Act by such order as aforesaid.

"Solid matter" shall not include particles of matter in suspension in the water.

"Polluting" shall not include innocuous discolouration. With certain modifications, such as substituting the Secretary of State for Scotland for the Local Government Board, the Rivers Pollution Prevention Acts also apply to Scotland.

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